Vol. XLIX

TABLE OF CONTENTS.

No. 6

(20 pages; no inset.)

Page

ENGINEERING NEWS OF THE WEEK 117

LEADING ARTICLES:

The Evolution of the Hydraulic Elevator; High-Pressure Elevators in the Prudential Buildings, Newark, N. J. (illustrated) ..... Chas. L. Duenkel, M. E. 118

Elnathan Sweet (With Portrait) 124

Fall of a Highway Bridge at Trenton, N. J. 125

A Steam Engine with a Single Rotary Valve (illustrated) 125

Proposed Canadian Standard Specifications for Portland Cement 129

Tests of the Friction of Ball-Bearings ..... M. J. Golden, M. Am. Soc. M. E. 129

Niagara Falls Power Supply Interrupted by a Fire ..... O. E. Dunlap. 129

The Cole-Flad Photo-Pitometer and Its Use In Studying Water Consumption and Waste (illustrated) 130

Annual Meeting of the Canadian Society of Civil Engineers 131

The New Mill Creek Power Plant of the Edison Electric Co., Near Redlands, Cal. (illustrated) ..... E. Duryee. 133

Smoke Prevention at St. Louis, Mo. 134

Investigations of Water Waste in New York City (illustrated) 135

Experience with Foundations in Boston 136

EDITORIAL COMMENT.—The Car Stove as a Factor in Recent Train Accidents—Oil-Burning Locomotives as a Danger Factor in Accidents—More Investigations Needed Concerning Cement and Concrete—The Movement to Widen the Field of the Canadian Society of Civil Engineers 126

EDITORIAL.—Some Lessons of Recent Collisions 126

LETTERS TO THE EDITOR.—"Rotting" of a Concrete Sidewalk by Manure: Leon D. Conkling—What Shall Be Done for Absent-Minded Locomotive Engineers?: "Mercy"—The Compensation of Engineers: I. Y. W.—The Electric Smelting of Iron Ore: Marcus Ruthenburg—The Merits and Demerits of Various Types of Joist Hangers: E. Haupt and F. E. Kidder—Shipments of Dynamite by Rail: The Climax Powder Co. and W. H. Bolander—A Question and Answer Regarding Explosive Tests of Joveite: G. W. Hughes—Experience with the Metric System in Mexico: John W. Miles—Experience of a Well-Known Engineer with the Metric System in Foreign Countries: S. W. Stratton and E. L. Corthell 127, 129

WORK ON A CANAL from St. John's, on the Richelieu River, to the St. Lawrence River opposite Montreal, is to be begun this spring, according to press dispatches. The canal is to be built under a charter amended and re-enacted at the last session of the Dominion Parliament. The charter provides that the canal shall have a depth of not less than 9 ft. and a width of not less than 80 ft. at the bottom. As a matter of fact, it will, it is stated, have immediately a depth of 14 ft., corresponding with that of the St. Lawrence canals. Its length is 18¼ miles. The present connection between Lake Champlain and the St. Lawrence is by the Richelieu River, which is its outlet, and the Chambly Canal, the oldest of the Canadian artificial waterways. The Chambly Canal reaches the St. Lawrence at Sorel, 45 miles below Montreal, and is a 7-ft. waterway, with locks 18 ft. wide. It was built when the seaport to which access was desired was Quebec. It makes the route to the St. Lawrence 105 miles long. This distance to free river navigation is reduced 83 miles by the proposed canal from St. John's to Montreal.

STEAM MOTOR CARS FOR STREET RAILWAY use have been built for the Compania de Tranvias de Merida, Yucatan. The cars were built by the John Stephenson Company, of Elizabeth, N. J., and the Reeves Engine Co., of Trenton, N. J., the former of whom supplied the car itself, while the latter furnished the machinery. The cars are only about 14 ft. long, and run on a 3-ft. gage track; as they have only a single truck, the space for the machinery was very restricted. The inside of the car is left free for passengers. The boiler, a vertical cylindrical tubular oil-burning boiler about 2 ft. by 2 ft., is located on the front platform, together with the reverse lever, the feed pump, and other accessories. A steam pressure of 225 lbs. is carried. The engine, a small compound of marine type, lies horizontally between the wheels. It has 3½ and 6½-in. cylinders of 6-in. stroke, and two piston valves. The crank-shaft is geared to one of the axles by a Renold chain, and a similar chain couples the two axles. The gear ratio from crank-shaft to axles is about 1 to 3. The cars are to be used for freight hauling (by trailer cars), as well as for passenger transportation.

AN EXCEPTIONALLY FAST RAILWAY RUN was made on the New York Central & Hudson River R. R. on Jan. 29. The Empire State Express, a fast train running between New York City and Buffalo, N. Y., covered the distance between Palmyra and Macedon, N. Y., 7.29 miles, in four minutes flat. This corresponds to a speed of about 109 miles per hour. This performance was made in the course of an unusually fast trip, the distance between Albany and Buffalo, 302 miles, being covered in 295 minutes, which represents an average speed for the whole trip of nearly 62 miles per hour.

THE MOVEMENT OF SAND ON BEACHES by winds of different velocities was made the object of observation by Mr. James H. Bacon, U. S. Assistant Engineer, in charge of work on the improvement of Cumberland Sound, Georgia and Florida, during 1902. The results of Mr. Bacon's observations are printed in the Report of the Chief of Engineers, U. S. A., for 1902, and are as follows:

(1) The sand between the high-water mark and the succeeding low-water mark is never moved by wind, no matter what the velocity may be.

(2) The movement of sand wet by rain varies inversely with the amount of moisture and directly with the velocity of the wind.

(3) The movement of dry sand depends only on the velocity of the wind and the configuration of the ground. On a flat beach the movement, under a wind of steady velocity, is constant. Among sand dunes and hills the movement is complex, but as a general rule the sand is taken from the windward side and deposited on the leeward side, or is blown from one dune and is deposited on another. As the beaches here are seldom flat for any great area, it is impossible to arrive at any reliable conclusions as to the amount of sand moved on them under any given condition. From observations made on a flat portion of the beach of Amelia Island the following deductions have been made:

Under a wind blowing northeast at an average velocity of 14 miles per hour there would pass over a line 3,000 ft. long 160 cu. yds. in 24 hours. Under a wind blowing northeast at an average velocity of 24 miles per hour there would pass over the same line 500 cu. yds. in 24 hours. These figures are approximate and cannot be relied on for any exact calculations.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a butting collision between two fast passenger trains, which occurred on the Southern Pacific Ry., about 15 miles east of Tucson, Ariz., on Jan. 28. About twenty persons were killed in the wreck and in the fire which followed. The cause of the wreck was the failure of an operator to deliver a meeting order to one of the trains. The west-bound train, called the Sunset Limited, was running late; at Vails Station there was an order for this train directing it to meet an eastbound freight train at Wilmot, about 15 miles west of Vails, and another order to pass the Crescent City Express, an eastbound passenger, at Esmond, about five miles west of Vails. The operator at Vails delivered the former order, it seems, but not the order concerning the express. As a result, when about six miles out from Vails, the Sunset Limited crashed into the latter train, both going at full speed; a curve prevented any warning and slowing down. The two trains were completely wrecked. A noteworthy feature is that both engines were oil-burners, and the oil tanks of the tenders were burst by the collision, so that the oil escaped. The fire in the wreckage was rendered extremely intense and rapid by this oil, and the attempts at rescue were much hampered. Among the other fatal train accidents of the week two are noteworthy as resulting from cars running away down grade. At Vicksburg, Miss., several cars broke away from a train on the Queen & Crescent Ry. on Feb. 1 and ran down grade into a river. It is thought that several persons were in one of the cars. A coal train on a branch of the Pennsylvania R. R. ran down a grade near Johnstown, Pa., on Jan. 30, and when at high speed jumped the track, killing one man. A butting collision on the Pennsylvania R. R., near Hazleton, Pa., on Jan. 30, was due to a partial failure of the train order system. An express passenger train and a freight train were to pass at a siding, but the freight, which (alone?) had received orders to pass, did not reach the siding in time.

A LARGE LANDSLIDE BLOCKED the New York Central and Hudson River R. R. for 24 hours, from 7 p. m. on Jan. 30, until the evening of Jan. 31. A few miles north of Staatsburg, N. Y., the double-track line of the road passes through a deep cut in land sloping west to the Hudson River. The cut is up to 50 ft. deep on the east side, and this portion, for a length of several hundred feet, suddenly slid into the cut, filling it with 20 to 40 ft. of earth. The rock surface slopes to the west at this point, and the overlying earth is sand and yellow clay. This material was softened by a strong thaw, and slid on the sloping surface of the rock. It is curious to note that two other landslides occurred in New York state at nearly the same time as the preceding, both of which nearly had fatal results. On Jan. 29, a cut on the Lehigh Valley R. R., near Brookton, N. Y., caved in and blocked the track. A passenger train ran into the obstruction and was wrecked, but the engine-runner was the only person injured. On the morning of Jan. 30 a bank of earth overlooking the works of the Mica Insulator Co., at Schenectady, N. Y., slid down and destroyed two of the factory buildings. Nobody was hurt in the accident.

A FATAL BOILER EXPLOSION occurred on Jan. 28 at the malleable iron foundry of the Southern Car & Foundry Co., at Anniston, Ala. Six men were killed outright and several were injured. The cause of the accident is not known.

UNUSUALLY HIGH DAMAGES have been awarded for the deaths and injuries resulting from the Park Ave. tunnel collision, which occurred on the New York Central & Hudson River R. R. about a year ago. The company made settlements in some of the cases, but the larger number of the claims came to trial. Up to the present nearly twenty damage verdicts have been returned, in amounts ranging up to $80,000 and $100,000, probably the two highest verdicts for such cases ever known. The aggregate of the verdicts is nearly $500,000.

AN OIL STORAGE TANK OF STEEL collapsed at Point Richmond, Cal., on Jan. 21, killing two workmen and seriously, if not fatally, injuring four others. The tank was located on a bluff, had a capacity of 35,000 bbls., and was being filled with water for testing when it suddenly collapsed. The tank was being built for the Standard Oil Co. to supply shipping.

A WOOD STAVE WATER TANK BURST at Hattiesburg, Miss., on Jan. 24, badly injuring several men. The tank had just been finished and was being filled with water when the hoops gave way. It appears that the tank was built for some one of the four railway lines entering Hattiesburg.

THE WORKS OF THE SYRACUSE REDUCTION CO. were destroyed by fire on Jan. 18, with a loss (insured) placed at $50,000. The plant, which was described at length in Engineering News of Oct. 11, 1900, was of the Holthaus type, and were put in operation in 1898, and a fertilizer manufactory, to utilize the tankage, was added in 1899. The plant had a capacity of 50 tons, and was housed in four wooden buildings. It is supposed that the fire, which occurred at night, originated in the engine room. The fertilizer factory and barn were the last to take fire, the main building and office going first. Mr. John Dunfee, of Syracuse, is President of the company. It is reported that the plant will be rebuilt on the old site at once, but with an increased capacity.

AN ACCIDENT TO A DIRECT-CURRENT lighting system is reported from Hull, England. The lighting supply in that system is direct-current at 220 volts; the distribution is high-tension, direct-current, transformed at substations to low-tension by rotary transformers. At the substations the high-tension lines were provided with automatic circuit-breakers. On Jan. 12, 1903, the four generators in the main generating station broke down simultaneously, and the supply to the entire town was interrupted for several hours. An investigation showed that there were several faults in one section of the low-tension distribution network, and at the time the evening load came on these faults caused the high-tension circuit-breaker of the transformer supplying this section to open. Under the heavy current the circuit was not broken, a strong arc being formed at the circuit-breaker; this arc, moreover, flared across to the adjacent switch of another transformer, and thus partially short-circuited the high-tension bus bars. The main generators, under these conditions, flashed at the commutators so badly as to necessitate immediate shut-down. On examination it was found that the armature of one generator required repairs to the winding, while the other three generators were able to run after having their commutators cleaned up. The engineer of the plant says in his report that he "is in consultation with the makers as to improving the operation of these switches."

TO DO AWAY WITH SMELTER FUMES has been undertaken in earnest by the Anaconda Co. at Butte, Montana. Experiments on a large scale are now being conducted by experts with this end in view.

PROGRESS ON THE SIMPLON TUNNEL for the month of December, 1902, is reported in the "Schweizerische Bauzeitung" as follows: The advance of the south heading was 478.8 ft., that of the north heading 682.2 ft., a total of 1,161 ft.; the average daily progress was thus, respectively, 17.09 ft. and 23.09 ft.; total, 40.18 ft. The south heading lay throughout in schistose gneiss, the north heading partly in the same rock, partly (from km. 8.306) in calcareous mica-schist carrying some pyrite. The average working force was 3,015, of whom 2,184 were employed within the tunnel. The conditions as to water did not change during the month. The total advance of headings up to the end of December, 1902, is: South end, 18,217.5 ft.; north end, 27,778.3; a total of 46,995.8 ft.

THE EVOLUTION OF THE HYDRAULIC ELEVATOR; HIGH-PRESSURE ELEVATORS IN THE PRUDENTIAL BUILDINGS, NEWARK, N. J.

By Chas. L. Duenkel,* M. E.

The elevator plant installed in the buildings of the Prudential Insurance Co., Newark, N. J., is of more than ordinary importance, not so much on account of its magnitude, as from the fact that it represents the highest development of modern elevator engineering practice. As the literature of elevators is very scanty, it may be well before proceeding to describe this installation to give a brief retrospect of the history of the modern elevator, showing the evolution through which elevator machinery has passed to reach the degree of perfection exemplified in the system installed in the Prudential Buildings.

The hydraulic elevator came into the field about 25 years ago, and soon superseded the steam machine then in use; it enabled the operator to control the movement of the elevator with far greater precision, and gave a smoothness of motion not obtainable with the old machines. For several years the pressure required to operate the hydraulic elevators was obtained by placing an open tank on the roof of the buildings, the pressure in the hydraulic cylinders varying from 30 to 40 lbs. per sq. in.

Then the height and size of buildings began to increase, which called for greater elevator speed and power. To obtain this without making the elevator cylinders too large, the pressure was increased to 100 lbs., then to 125 lbs., and pressure tanks located in cellars replaced the open roof tank with its long run of pipe. About this time, also, the old hand-rope control in the car was replaced by the lever device; this was connected with a pilot-valve which in turn operated the main valve controlling the supply of water to the elevator cylinder.

About 12 years ago the height and size of buildings became such that the number of elevators required to give satisfactory service was much greater than in former years; hence, economy in space and operation became important factors. There was keen rivalry among the different important elevator builders in the field in those days to increase the efficiency of operation of elevators. In this competitive striving a system was brought out in 1892 which enabled the working pressure of the water to be increased to 750 lbs. per sq. in., thus reducing considerably the size of the apparatus required.

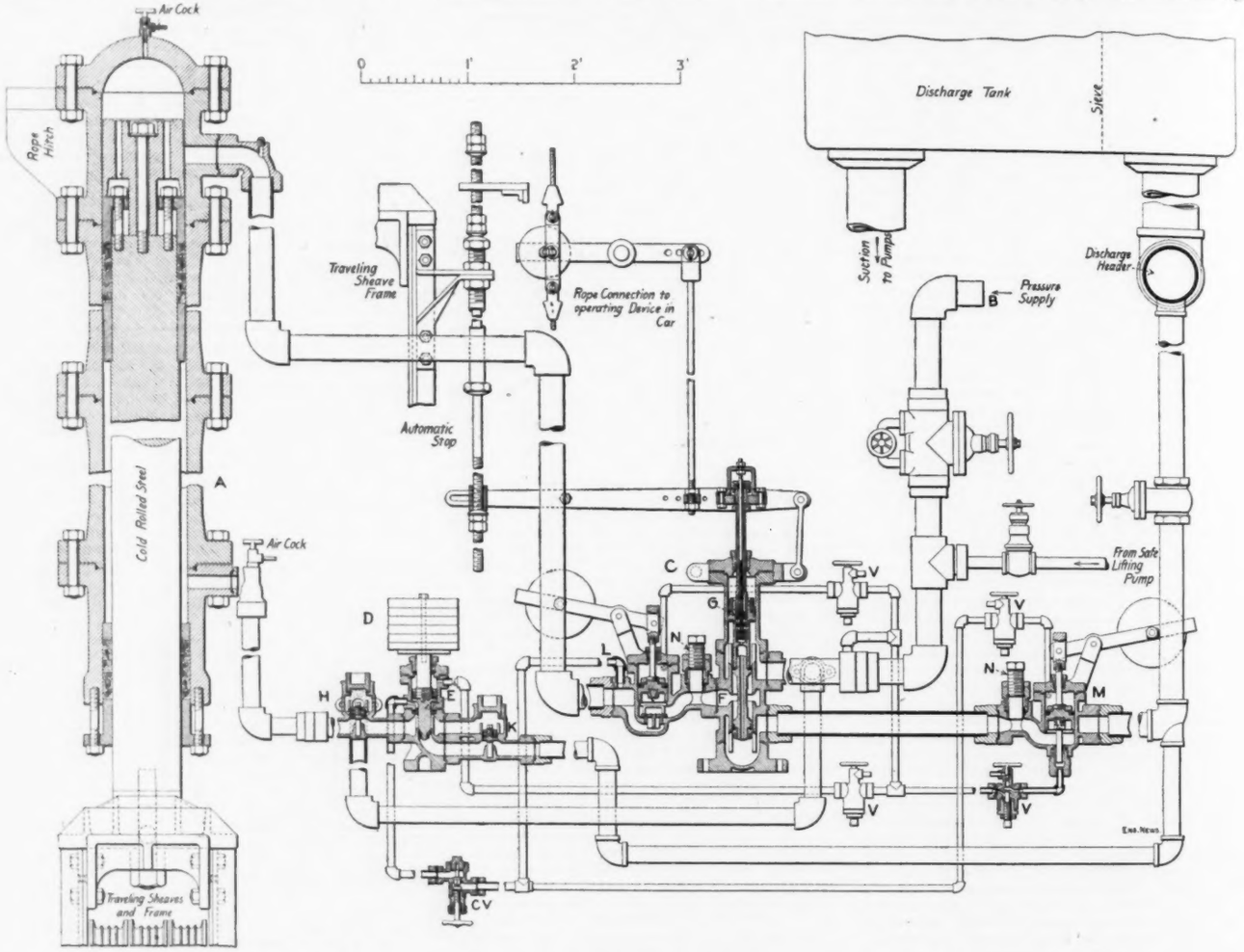

FIG. 1. THE DIFFERENTIAL HYDRAULIC ELEVATOR; GENERAL ARRANGEMENT AND DETAILS OF CYLINDER AND VALVES.

A. Elevator Cylinder with Differential Piston.
C. Starting Valve with Inside Pilot.
D. Automatic Change Valve.
H. Circulating Check Valve for Light Loads Ascending.
K. Suction Check Valve, Car Descending.
L. Speed Governor for Ascending Car, with Check for Reverse Flow.
M. Speed Governor for Descending Car.
N. Screw Throttle Valve.
V. Stop Valve with Drain.
CV. Combined Check and Stop Valve.

THE DIFFERENTIAL HYDRAULIC ELEVATOR.

This system was called the "differential" system. As no description of it has ever been published, the drawing Fig. 1 is presented herewith to show the arrangement and operation of the machinery which constitutes this system.

In Fig. 1, the hydraulic cylinder and plunger, which operate the car, are shown at A, at the left of the drawing. The cylinder is suspended, closed end up, and the traveling multiplying sheaves are fastened to the bottom of the plunger; the stationary sheaves, which work with the traveling sheaves, are set above the cylinder. The pressure water is supplied by pumps and accumulators (not shown) by way of the pipe B. The plunger working in the hydraulic cylinder is really a piston, arranged so that pressure water can be admitted both above and below the piston; the difference in the areas of the two spaces gives a net downward pressure on the piston corresponding to the cross-section area of the plunger body or stem. Provision is also made, however, to admit pressure water only above the piston, exhausting the water below the piston into a discharge tank; this arrangement gives a greater net downward pressure on the piston than in the other case. Since the downward motion of the piston corresponds to upward motion of the elevator car, this differential arrangement gives two different degrees of lifting power, suited for light and heavy loads, respectively; the pipe connections are changed from the double-acting or differential to the single-acting system by an automatic change-valve, so that the operator has only to work a main or starting valve by means of rope connection, as in previous hydraulic elevator machines. The elevator is "underbalanced," i. e., its light weight is greater than that of counterweights, plunger, etc., reduced by the gear ratio; the elevator, therefore, does not need to be lowered, but goes downward when both sides of the piston are connected to the discharge system. An automatic check-valve acts to admit water from the discharge system below the piston when the space above the piston is exhausted into the discharge by the starting valve. The elevator car then goes down by its own weight, pulling the plunger up. The check-valve is weighted so as to govern the downward speed of the car.

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The action of the machinery may be followed out in detail by reference to our drawing Fig. 1. The starting valve, C, is actuated by rope connection from the car, and controls the admission of water above the elevator piston. The automatic change-valve is shown at D; it controls the water below the elevator piston. It is actuated by a small valve-piston E, above which there acts the full pressure of the supply water, while below it acts the pressure of the water which has passed through the starting-valve C. Therefore the action of the change-valve D depends upon the difference of pressure across the starting-valve; that is, upon the amount of throttling produced by the latter.

The normal position of change-valve D is down, forcing the discharge from the lower side of the piston through a check-valve into the high-pressure system. With a lightly-loaded car the throttling across the starting-valve C is sufficient to give a difference of pressures which keeps the valve D down, thus producing the differential action. With a heavy load on the car, however, the throttling across C is small, so that the pressure on the delivery side is able to lift the valve-piston E (acting on the larger area of its lower surface), and thus raise the valve. The water from the lower side of the elevator piston is then able to pass directly into the discharge system, which gives a greater net lifting power. The saving of water due to the differential action, in the case of a light load on the car, is the main feature of the differential system.

The construction of the starting-valve C deserves to be studied. The valve-plug F controls the admission of pressure water to the upper part of the elevator cylinder as well as the exhaust therefrom. The plug F is moved by the piston G, against the lower side of which the supply pressure (750 lbs. per sq. in.) is constantly acting. Water may be admitted above piston G by moving a small central pilot-valve downward; when this is done, piston G moves downward by virtue of the larger effective area of its upper surface, thus connecting the elevator cylinder with the discharge system. If the pilot-valve be moved upward, the water above piston G is exhausted through the bore of the main valve-plug, and the piston with the attached valve-plug then moves upward, connecting the supply pipe with the elevator cylinder. It will be noticed that the flow of water through the pilot-valve is cut off by the motion of the valve-plug F, so that the latter only moves a certain amount corresponding to the motion of the pilot-valve.

The drawing also shows how the automatic stop, at top and bottom of the elevator shaft, was obtained with this system. When the elevator car nears either end of its travel, a stop connected with the traveling-sheave frame strikes an extension of the operating lever of starting-valve C, and thus closes this valve (i. e., cuts off the admission or the exhaust of the water, as the case may be). The two stops are formed by nuts mounted on a vertical rod hung from the frame; in this way the stopping point may be closely adjusted. This automatic stop is so arranged that if at any time the pilot valve of C should stick or get out of order, the automatic stop acts directly on the main valve and forces it bodily either up or down.

The "Differential" system of hydraulic elevators was applied for the first time in the elevators of the Glasgow Harbor Tunnel, Glasgow, Scotland; soon afterward elevators of this type were installed in the building of the American Tract Society, New York, and later in the Girard Bldg., Philadelphia. Some disadvantages of the system soon became evident, however, mainly the two following:

The pilot-valve already spoken of, which is the part directly moved by the operating lever, and which controls the water for operating the main valve-plug, is a brass tube of small diameter, and the ports through it are radial holes 1-64-in. in diameter. This valve, it was found in actual operation, was rapidly worn by the high-pressure water flowing at high velocities; the pilot-valve and its seat became deeply grooved, and the small ports were worn larger; the leakage past the valve then was such that the control of the elevator was extremely imperfect, and the operator could not maintain his floor landings. The automatic change-valve, the main feature of the system, also gave trouble. It was often somewhat undecided in its action when on or near the balancing point, and then produced a car motion which was not uniform.

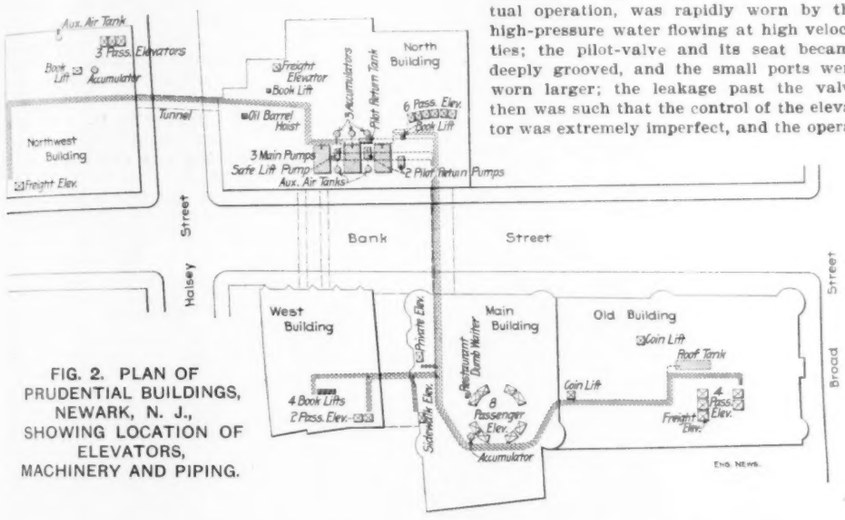


FIG. 2. PLAN OF PRUDENTIAL BUILDINGS, NEWARK, N. J., SHOWING LOCATION OF ELEVATORS, MACHINERY AND PIPING.

These disadvantages were so serious that the "Differential" system was soon abandoned. The Glasgow plant is still in operation; but that in the American Tract Bldg. has been all removed, while the Girard Bldg. elevators have been substantially altered by removing the starting-valve, with its high-pressure pilot-valve, and substituting for it a new design of starting-valve having a low-pressure pilot, supplied by separate pipes.

During the period when this type of hydraulic elevator was being tried, and the ordinary low-pressure hydraulic machine had been found too bulky and generally unsatisfactory for high buildings and large installations, the electric elevator (drum operated) was widely introduced. It still holds a fair share of the field, though it has been decisively beaten by the hydraulic elevator in the improved types described in the following.

THE TWO-PRESSURE HYDRAULIC ELEVATOR.

In 1896 the "Two-Pressure" or double-power system, using two pressure-tanks, was put upon the market, to realize the saving in energy for which the differential system was designed. This consists in the use of two pressure tanks, one carrying 100 lbs., the other carrying 200 lbs. An operating valve with pilot-valve is employed, using either of the pressures, according to the position of the operating lever. With a light load ascending in car the operator moves his lever far enough to connect the 100-lb. system with the lifting cylinder, while if the load to be lifted is above the average, he moves his lever to the extreme limit, which brings the 200-lb. system in operation; a check-valve prevents the high-pressure water from getting into the low-pressure piping.

The "Two-Pressure" system was first applied in the elevators installed in the St. Paul Bldg.; its second and third application were in the Bowling Green Bldg. and the Standard Oil Bldg., all three on lower Broadway, in New York city. It will be noted that the system is not automatic in changing from one pressure to the other, so that the operator can use the high pressure for very light loads, which gives undesirably high speeds. The two-pressure system is still being installed, and is still in regular use in the above-named buildings where it was first applied.

During this latter installation came the development of the "Duplex" or two-motor system of electric elevators. This system involves two motors running in opposite directions, grooved sheaves, or drums being keyed direct to the armature shafts; the endless hoisting rope runs over these sheaves and over other sheaves on the elevator and on a geared counterbalance frame. With equal speed of both motors, no motion of car is obtained, but by varying the speed of either motor the car is moved in either direction. This system has been commented upon on account of the small diameters of the drums, and the high rope velocities necessary.

Within the last year or two has come the development of the plunger or direct-lift elevator. This type has advantages under certain conditions. Its largest application to date has been in the 17-story Ansonia apartment hotel, at Broadway and 74th St., New York City, where some fifteen elevators of this type have been installed.

THE HIGH-PRESSURE ELEVATOR—PRUDENTIAL BUILDING ELEVATORS.

The hydraulic elevator has thus been developing in the direction of high-pressure operation for a number of years past. Passing through the stages of development above mentioned, it has finally assumed its latest form in the elevator system installed in the Prudential Buildings. This installation is described in the following: A high-pressure supply, at 750 lbs. per sq. in., furnishes water for the operation of the elevator cylinders. The admission and exhaust of the water are controlled by a valve operated by a pilot-valve; the pilot supply is at low pressure, 82 lbs. per sq. in. The variations in speed under varying loads are controlled by a speed regulator, located between starting-valve and cylinder, which throttles the flow of the water under the influence of a spring. A close regulation is obtained, and with the high pressure the loss due to the throttling is unimportant. These are the essential features of the system applied in the Prudential Bldgs.

GENERAL DESCRIPTION.—The buildings comprised in the group in question are five in number; the various elevators, passenger, freight, and miscellaneous, are served from a central power plant. The piping is carried in tunnels under the streets which separate the buildings. The advantage of the economy in piping which the high-pressure system secures is especially important with this arrangement. Fig. 2 shows the different buildings in the group, and indicates the location of the elevators and the piping.

The Old Building was erected (in part) in 1891, and contained five hydraulic elevators operated under 125 lbs. pressure from a closed tank; the pressure in the tank was 43 lbs. per sq. in., while 82 lbs. pressure was obtained by the gravity head. The machines (vertical) were of the suspended or tension type, with cylinders 16 ins. in diameter, and were geared in the ratio six to one. In 1899 the new buildings were started and a new and comprehensive elevator system was decided upon. The old pumps were replaced temporarily by Quimby screw pumps direct-connected to electric motors, and the elevators were run this way until the completion of the new system.

In the completed high-pressure installation, shown in Fig. 2, the five elevators in the old building have been remodeled to "High-Pressure" machines, and two direct lifts have been installed to carry coin, etc., to and from the safe deposit vaults of the Fidelity Trust Co., on the first floor. The roof tank is now used as an open discharge

tank for the elevators in all the buildings. These are divided as follows:

Main Bldg.: (12 stories.)	9 passenger elevators. 1 dumbwaiter (book lift). 1 double-ram direct lift (sidewalk hoist).
West Bldg.: (10 stories.)	2 passenger elevators. 2 book lifts.
Northwest Bldg.:	3 passenger elevators. 1 freight elevator. 1 book lift.
North Bldg.: (11 stories.)	6 passenger elevators. 1 freight elevator. 2 book lifts. 1 hoisting crane.
Old Bldg.:	4 passenger elevators. 1 freight elevator. 2 coin lifts (direct lifts).
Total:	37 machines.

Of these the hoisting crane is a special form of plunger lift, having a goose-neck standard with chain and hook, instead of a platform. The double-ram sidewalk hoist and the two coin lifts are direct-lift or plunger machines. All the passenger and freight elevators, and the dumbwaiters (book lifts) are of the rope-operated style of elevator. They are all operated by water at a pressure of 750 lbs. per sq. in., but one elevator in each building is arranged so that it can be run under a pressure of 1,500 lbs. per sq. in. for lifting safes.

The passenger elevators are designed to lift 1,500 lbs. each at a speed of 500 ft. per minute, or 2,500 lbs. at 250 ft. per minute. Safes are lifted at a speed of 25 ft. per minute. The book lifts can carry 800 lbs. each, at a speed of 300 ft. per minute, and the coin lifts have a capacity of 2,500 lbs. at a speed of 50 ft. per minute.

The entire pumping machinery is located in the basement of the North Bldg. This comprises the following:

3 Flywheel pumps, pressure 750 lbs. per sq. in., capacity 370 gals. per min. each.
2 Direct-acting return pumps, pressure 82 lbs. per sq. in., capacity 300 gals. per min. each.
1 Safe-lifting pump, pressure 1,500 lbs. per sq. in., capacity 30 gals. per min.
1 Air pump, Westinghouse air-brake pump.
3 Weighted accumulators, 12-in. diameter by 11-ft. stroke, pressure 750 lbs. per sq. in., capacity 68 gals. each.
2 Equalizing discharge tanks, pressure 82 lbs. per sq. in., capacity 1,250 gals. each.
1 Open tank for pilot return, capacity 1,100 gals.

In addition, there is a pressure-equalizing accumulator in the Main Bldg., and in the Northwest Bldg. an accumulator and an equalizing-discharge tank (82 lbs. pressure).

The piping comprises five general systems: (1) the main pressure system, 750 lbs. pressure, extra heavy pipe; (2) the discharge system for all elevators, under a gravity head of 82 lbs. per sq. in.; (3) the pilot-valve discharge or return system at 0 to 10 lbs. pressure; (4) the safe-lifting system, 1,500 lbs. pressure, double extra heavy pipe; (5) the air-pressure system, for charging the air chambers and tanks, pressure 180 lbs. per sq. in. In all the hydraulic piping air-cocks are placed at the high points, where air might collect.

A diagrammatic drawing of the machinery for one elevator is shown in Fig. 3. The central part of this diagram is drawn to twice the scale of the remainder, to show more clearly the main and pilot-valves, speed regulator, spring chambers, etc. The drawing is sufficiently detailed that a brief description will be sufficient to fully explain the operation of the system.

The operating cylinder is of the inverted plunger type, geared six to one. It is suspended from beams located near the top of the building and is suitably secured sidewise. The plunger passes through a cylinder head with a stuffing box at the lower end whose internal diameter is greater than that of the plunger so as not to obstruct the flow of water. When the operating lever in the car is thrown to the right the main-valve is moved in the proper direction to connect the cylinder with the high-pressure (750 lbs.) pipes, the plunger is forced down, and the elevator car goes upward. On the downward trip of the car the water in the cylinder is discharged into the 82-lb. system connected with the roof tank and equalizing tanks. The water from this system passes through the pilot-valve and acts upon the piston that moves the main valve. From the pilot-valve the water is discharged into the 10-lb. system. The pilot return pump draws water from this tank and delivers it into the 82-lb. system. The main pump takes water from the 82-lb. system and delivers it into the 750-lb. pressure system. Accumulators connected with the high-pressure system are properly weighted to maintain a constant pressure of 750 lbs. per sq. in. The safe-lifting pump takes water at 82 lbs. and discharges it at 1,500 lbs.

The pumps are adjusted so as to deliver the amount of water required for the (two-minute) schedule of the elevators. Whenever the pumps get slightly ahead, the excess of water is forced into the accumulators and their plungers ascend. If the supply exceeds the demand for a sufficient length of time the accumulator will rise high enough to actuate the throttle valve of the pumps by means of the rope connection shown in Fig. 3; when this stage is reached, the pump comes to a stop, closing a 6-in. swinging check-valve in the supply pipe. By this check-valve, a small by-pass is opened from the delivery to the suction side; through the ½-in. opening of this by-pass water is forced momentarily, or until the pressure in the water end of the pump drops from 750 to 82 lbs. The flow of water through the by-pass actuates a steam-valve by-passed around the throttle, and

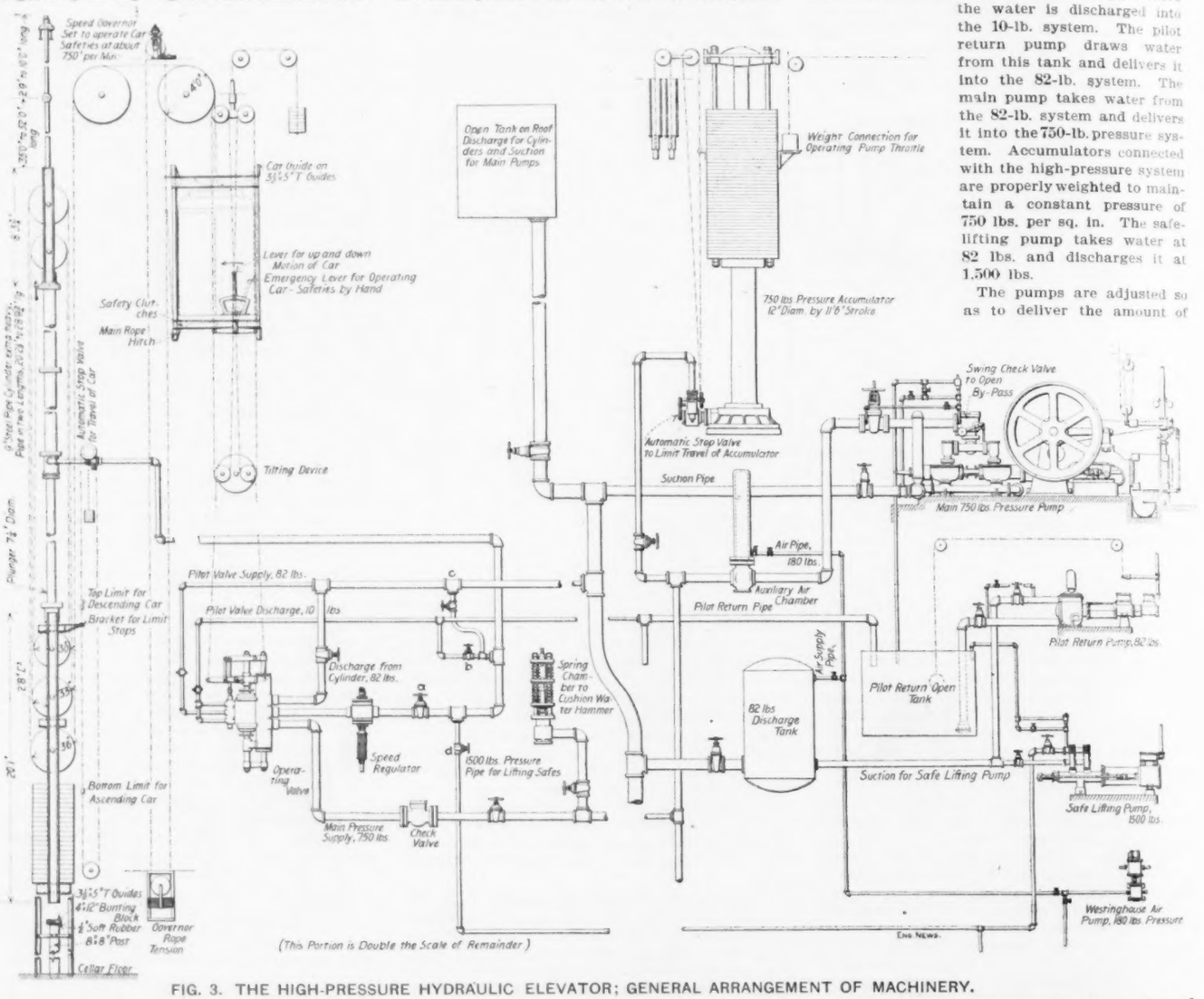

Speed Governor Set to operate Car Safeties at about 750' per Min.
Car Guide on 3½5" T Guides
Lever for up and down Motion of Car
Emergency Lever for Operating Car - Safeties by Hand
Safety Clutches
Main Rope Hitch
Automatic Stop Valve for Travel of Car
Tilting Device
Top Limit for Descending Car
Bracket for Limit Stops
Bottom Limit for Ascending Car
3½5" T Guides
4-12" Bunting Block
½" Soft Rubber
8-8" Posts
Governor Rope Tension
Cellar Floor
Plunger 74" Diam.
Open Tank on Roof Discharge for Cylinders and Suction for Main Pumps
Weight Connection for Operating Pump Throttle
750 lbs Pressure Accumulator 12" Diam. by 11'6" Stroke
Swing Check Valve to Open By-Pass
Automatic Stop Valve to Limit Travel of Accumulator
Suction Pipe
Main 750 lbs. Pressure Pump
Air Pipe, 180 lbs.
Auxiliary Air Chamber
Pilot Valve Supply, 82 lbs.
Pilot Valve Discharge, 10 lbs.
Pilot Return Pipe
Pilot Return Pump, 82 lbs.
Discharge from Cylinder, 82 lbs.
Spring Chamber to Cushion Water Hammer
Air Supply Pipe
Pilot Return Open Tank
82 lbs Discharge Tank
Operating Valve
Speed Regulator
1500 lbs. Pressure Pipe for Lifting Safes
Suction for Safe Lifting Pump
Safe Lifting Pump, 1500 lbs.
Main Pressure Supply, 750 lbs
Check Valve
Westinghouse Air Pump, 180 lbs. Pressure
(This Portion is Double the Scale of Remainder)
ENG. NEWS.

FIG. 3. THE HIGH-PRESSURE HYDRAULIC ELEVATOR; GENERAL ARRANGEMENT OF MACHINERY.

thereby admits a small amount of steam into the receiver connected to the low-pressure cylinders. The pumps are thus kept going very slowly, pumping water through the by-pass; in this way a quick start is insured when the pump is again called into action. As soon as the pump starts up the by-pass is closed automatically. These pumps are of the Laidlaw-Dunn-Gordon three-cylinder compound double-acting type, with Corliss valve-gear. The cranks are set 120° apart.

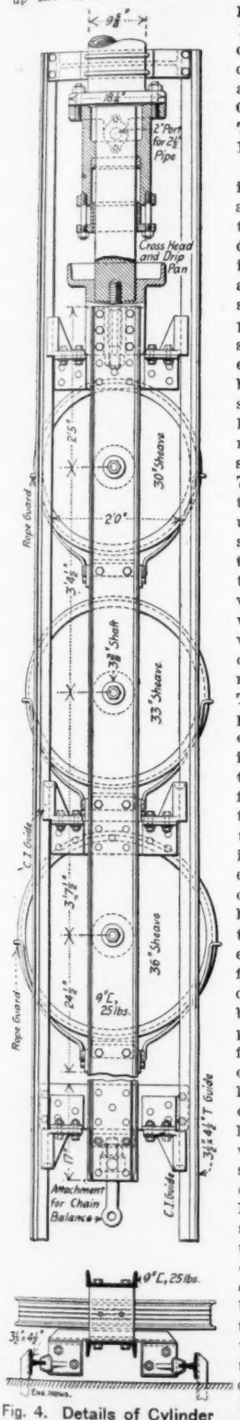


Fig. 4. Details of Cylinder Stuffing-Box and Traveling Sheave-Frame.

Each accumulator is provided with an automatic stop-valve to limit its up and down travel. Auxiliary air-chambers are provided to check small fluctuations in pressure, and a spring-actuated cushioning chamber is provided to destroy any water-hammer effects that may be produced by sudden strains on the 750-lb. piping system. The speed regulator adjoining the starting valve is for the purpose of maintaining a uniform velocity of the car when the starting-valve is opened sufficiently to give the maximum car speed. The pilot return pump is controlled entirely by the float in the pilot return tank and is not affected in any way by the pressure in the equalizing-tank into which it delivers. This pressure is obtained from the head of the roof tank. Air for the equalizing-tank and for the auxiliary air-chambers is supplied by the small air pump already referred to and shown on the right-hand lower corner of the diagram. The safe-lifting pump is used whenever it is desired to lift safes or other heavy objects. In such cases the starting-valve is not used, the car being controlled by means of the hand valves a, b, c, d, connected in the safe-lifting pipes; when lowering a safe the water is discharged into the 82-lb. system. The automatic stop-valve in the supply pipe, adjoining the operating cylinder, is for the purpose of stopping the car automatically at the top and bottom landings of the building, and is actuated by the projecting arm on the traveling-sheave frame which strikes stop balls secured in proper position to the rope that passes over the sheave mounted on the valve-shaft. The weight shown is for the purpose of bringing the valve to the central or inactive position as soon as the car moves away from the landing. The accumulator automatic stop is actuated in a similar manner, as is clearly shown in the diagram.

The equalizing accumulators placed in the Main and Northwest Bldgs. are for the purpose of preventing an excessive drop in pressure whenever there is an unusual drain on the system. If a number of elevators were set in operation at the same time in these buildings, the excessive amount of water required would cause a decided drop in pressure through pipe friction; in such cases the reserve capacity of the equalizing accumulators comes into play and holds up the pressure. They are weighted to a pressure somewhat lower than 750 lbs. per sq. in., so as to ensure their always being fully charged before the accumulators at the main pumps.

The preceding is sufficient, it is hoped, to make clear the arrangement and operation of this new type of hydraulic elevator. However, the general arrangement only has been shown and described; there is much that is interesting in the details of the machinery, and the accompanying drawings of the different parts are therefore presented, with the following brief explanatory references.

DETAILS OF MACHINERY.—Fig. 4 shows the lower end of the elevator cylinder and plunger, together with the traveling sheave frame. The sheaves are cast solid, and thus supply part of the necessary counterbalancing weight. The sheaves are arranged in tandem, and their diameters increase from the upper to the lower sheave, so that the different runs of rope may all be central and yet clear each other. In the dumb-waiter machines, which are much smaller, the sheaves are arranged side by side on one pin, instead of in tandem as in the main elevators.

The starting-valve with its pilot-valve, is shown in section in Fig. 5. As has already been stated, the pilot-valve A uses water at 82 lbs. pressure, from the discharge system of the elevator cylin-

Fig. 6. Throttling Speed Regulator.
(Set for a Car Speed of 500 ft. per min. in either direction. Stroke of valve = ¾-in. each way.)

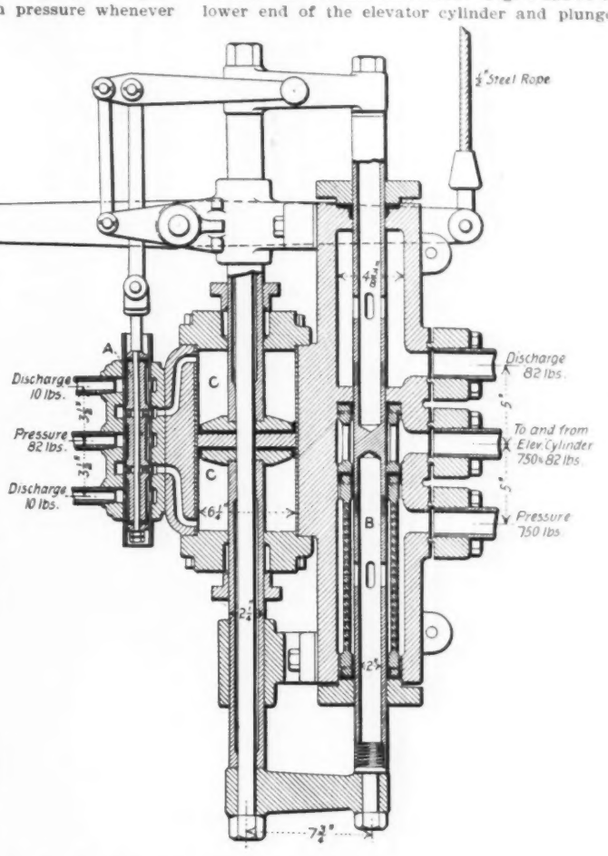


FIG. 5. LONGITUDINAL SECTION OF STARTING VALVE, SHOWING MAIN VALVE, OPERATING CYLINDER AND LOW PRESSURE PILOT-VALVE.

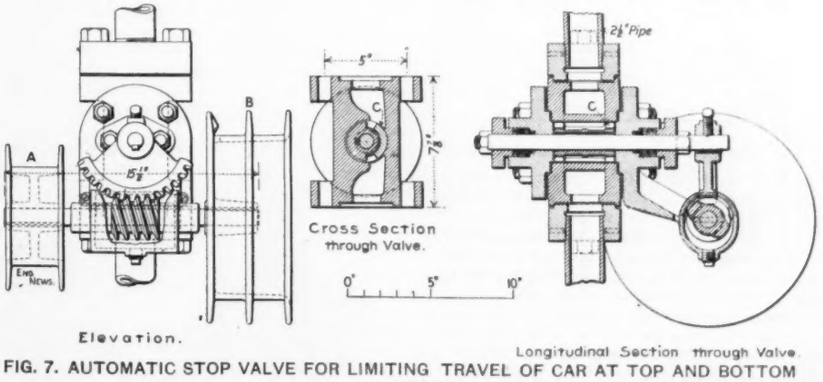


FIG. 7. AUTOMATIC STOP VALVE FOR LIMITING TRAVEL OF CAR AT TOP AND BOTTOM OF SHAFT.

Fig. 5 shows the lower end of the elevator cylinder and plunger,

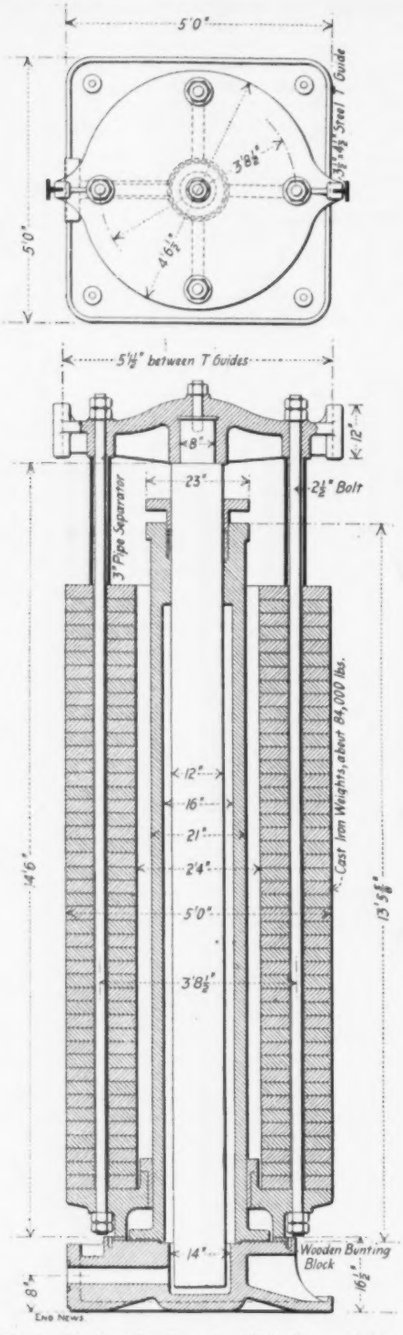


Fig. 8. Vertical Section of a Main Accumulator.

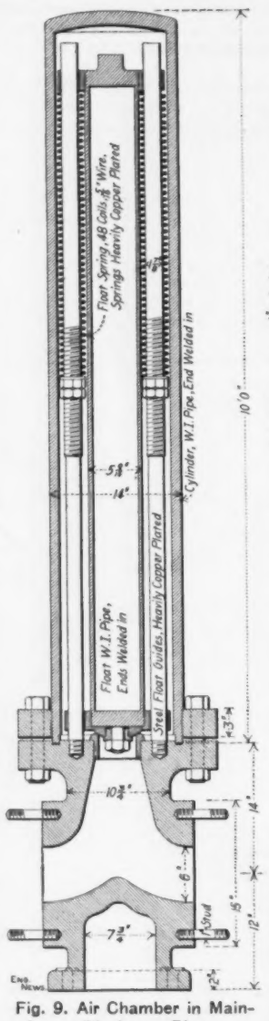


Fig. 9. Air Chamber in Main-Pump Discharge Pipe.

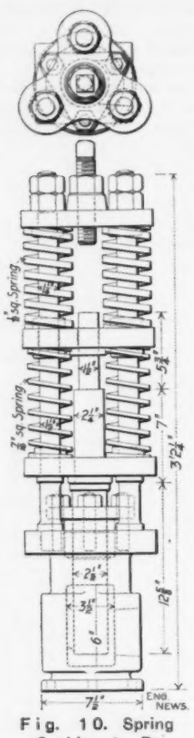


Fig. 10. Spring Cushion to Prevent Water Hammer in High Pressure Piping.

der, and returns it into a 10-lb. system. The main-valve B takes water at 750 lbs. pressure and discharges it at 82 lbs. This main valve controls the flow of water to and from the elevator cylinder; it is operated by a piston moving in a small cylinder C lying between the main-valve and the pilot-valve, the piston being connected to the stem of the main-valve by crossheads. The pilot-valve is for the purpose of controlling the flow of water to and from the cylinder C. The pipe connections for this valve are fully marked and the operation is as follows: If the operating lever is moved in the direction of the arrow the pilot-valve is moved downward, the water at 82 lbs. pressure enters the lower end of the operating cylinder C and forces the piston upward. As the stem of this piston is connected with the main-valve B, the latter will be lifted and thus the lower or high-pressure supply pipe will be connected with the middle pipe which runs to the elevator cylinder; the high-pressure water then enters the elevator cylinder and forces the plunger down, thus lifting the elevator car. If the operating lever is reversed the valve motion will be reversed, and the valve will be lowered so as to connect the cylinder pipe with the discharge system. When the piston C moves, it carries with it, by means of the system of links shown, the pilot-valve as well as the main-valve, hence if the operating lever moves the pilot-valve downward, as soon as the main valve B begins to ascend it will carry the pilot-valve with it, the latter returning to the central position; the admission of water will then be shut off by the pilot-valve and the motion of main-valve B will stop. In this way the stroke of B is made to correspond with the distance through which the operating lever is moved, so that the movement of the main-valve is as completely under the control of the car operator as if it were actuated directly by the operating lever.

Fig. 6 represents a section through the throttling speed regulator, which, as already explained, is situated between the starting-valve and the elevator cylinder. The theory of its action is that if, in a pipe or passage with an obstruction in it, the difference of pressure on the two sides of said obstruction is constant then the velocity of the water will be constant and independent of the pressure. The difference of head allowed in this design is about 20 lbs. per sq. in. The water passes through a series of ¼-in. holes in the main lining or bushing, then through the holes in the movable piston, where it is throttled, then out of the ¼-in. holes in the opposite side of the lining. The total pressure on the piston is greater on the flowing-in side, but is compensated for by the tension of the springs. This regulator is double-acting, i. e., it acts for both up and down motion of the elevator car. It regulates within 12% from no load to maximum load.

Fig. 7 shows the construction of the automatic stop-valve which limits the travel of the car at the bottom and top landings. This valve, as shown in Fig. 3, is actuated by an arm attached to the traveling-sheave frame, which strikes against stop balls placed on a rope that passes around sheave B of the automatic stop-valve. The centering weight is secured to a rope that winds up on sheave A. Both sheaves are mounted on a shaft which carries a worm meshing into a segment fastened to the end of the valve stem. The valve fastened to this stem has a movable part, C; this is forced out against its seat by the pressure of the water in effecting a stop, but whenever the elevator is reversed, the pressure forces the segment away from the seat as as to allow the water to pass through and set the plunger in motion. As soon as the car has moved a short distance, the centering weight brings the valve to the central or inoperative position, and the water then passes unobstructed. This valve is designed to stop the car within 15 ft. at the top and bottom landings independent of the operating lever.

The main accumulators are shown in Fig. 8; these are fed directly by the main pumps. The construction will be clear from the drawing. The weights on the plunger aggregate about 84,000 lbs.; they are hung on four bolts from the upper frame, and the outside of the cylinder is turned to guide them. When the weights are in their lowest position, they rest on hardwood blocks on the base of the accumulators, and pipe sleeves around the upper ends of the supporting bolts prevent the plunger from descending farther. The upper cross frame is guided by two stationary T-guides.

In the entrance and discharge pipe of the accumulator is an automatic stop-valve quite similar in action to the automatic stop-valve on the elevator cylinder. In this case, however, check-valve by-passes are provided for both the entrance and the discharge, so that the automatic stop-valve acts only to limit the stroke of the accumulator plunger, but does not prevent the passage of water in the opposite direction. The valve is actuated by a chain running over a sprocket, stop balls on this chain being engaged by an arm on the accumulator weights. The location of this valve is indicated on the general drawing, Fig. 3.

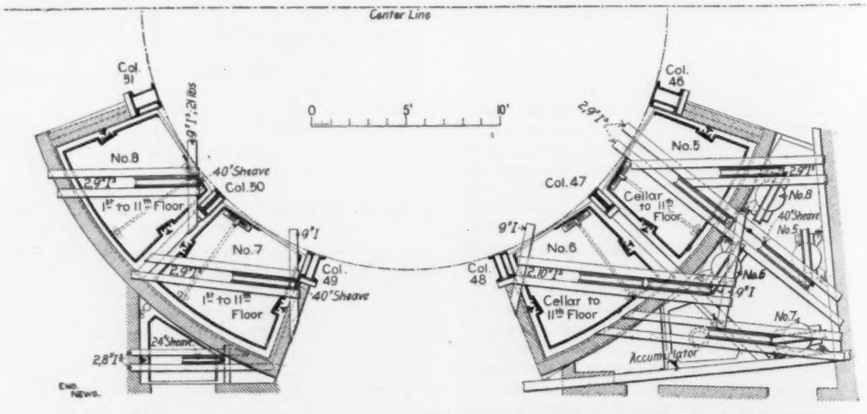
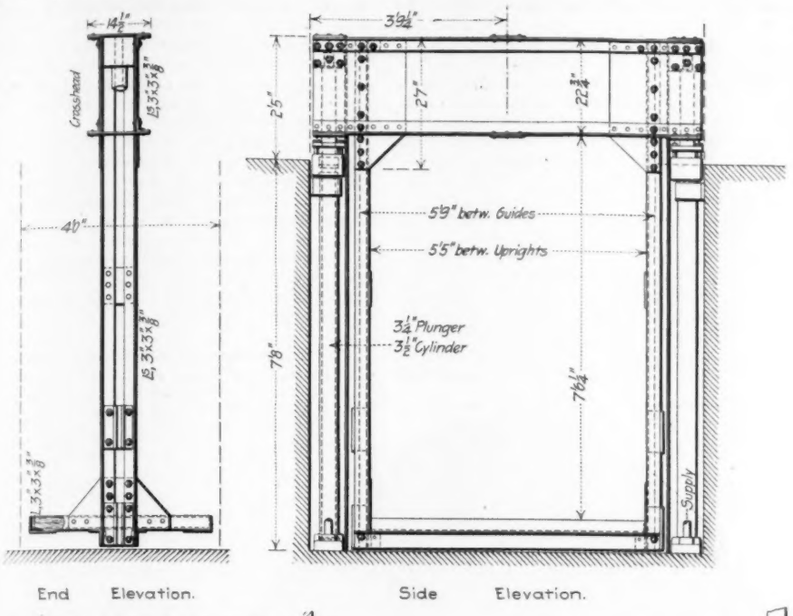


FIG. 11. PART LAYOUT OF PASSENGER ELEVATORS IN ROTUNDA OF MAIN BUILDING.



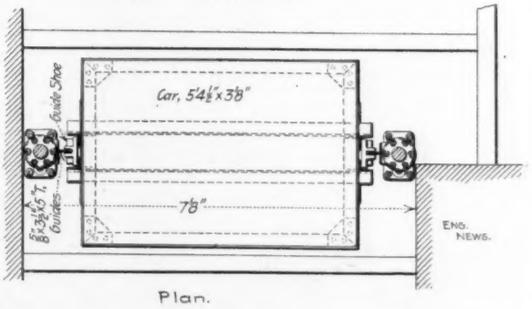


FIG. 12. DOUBLE-PLUNGER SIDEWALK HOIST.

The auxiliary accumulators, which are placed in the buildings at a distance from the pumps in order to hold up the pressure in case of excessive demand, are in general of the same construction as the main accumulators. In the Main Bldg., they had to be fitted into narrow irregular shaft spaces, and a slightly different construction had to be used. Here the weights do not surround the cylinder, but rest on the top of the plunger, being properly secured sidewise by fixed guides. This so-called "extended weight" pattern of accumulator requires much greater headroom, but this was available in the case mentioned.

The air chambers provided in the pipe between the pumps and the main accumulators are represented by the drawing Fig. 9. Their purpose is to smooth out pulsations in the pump discharge. As will be seen from the drawing, the lower end of the chamber is closed by a check-valve that forms the bottom of a float which is supported on springs that serve in part to carry the weight of the float and in part to prevent the valve pounding on the seat. The air is maintained by means of the 180-lb. air-pump. The principal object of having the check-valve is to prevent the air backing up into the system when the pressure drops.

Fig. 10 shows in plan and elevation the spring cushion or accumulator to take up the water hammer effect in the high-pressure piping system. These cushions are placed at the ends of long runs of piping. The drawing explains clearly the action of this device.

In connection with the preceding explanation of the details of the elevators in the Prudential Bldgs., Fig. 11, herewith, may be of interest. It is a layout (half only is shown) of the passenger elevators in the rotunda of the Main Bldg., and represents typically the arrangement of the elevator work throughout this installation, and, indeed, in modern high duty elevator work generally. It shows the elevator shafts, the shape of the cars, the location of the hydraulic cylinders, the overhead framing and sheaves, etc. It will be noted that the four elevator machines are grouped on the right-hand side. This was done for convenience of having the machinery together. The ropes from the cars on the left pass over to their respective cylinders on the right; these ropes are not shown on the drawing. The small dumbwaiter on the left has its cylinder located over the accumulator on the right; the beams for supporting the sheave over this cylinder are not shown. In regard to the absence of counterweight shafts, it will be seen from Fig. 3 that the weights are attached directly to the traveling sheave frame, the sheaves themselves supplying part of the required counterweight.

The dumbwaiters (book lifts) show an unusual detail in the arrangement of the guides for the cars. These cars are only 28 ins. square, and the two guides of each car are located at the front edge of the car instead of centrally or diagonally. This expedient was adopted to save shaft room, or rather, inversely, to give a larger car for a given size of shaft.

These dumbwaiters, moreover, while they are hydraulically operated, are not controlled by lever or rope, but by a push button system, similar to that used in electric residence elevators. The hydraulic equipment is quite similar to that of the main elevators, and the same starting-valve is used. The lever which shifts the pilot-valve of the latter is moved by electro-magnets. Each car is equipped with a series of pushbuttons corresponding to the floors which the dumbwaiter serves, and at each floor is also a pushbutton for each car. The operation of these cars is as follows: Suppose the car to be at the first floor. The door of the shaft at that floor is opened, and the button on the cage pushed, corresponding to the floor to which it is desired to send the cage. The cage does not move, however, until the door is closed, when the car starts itself, proceeds to the proper floor, and stops there, lighting an electric light at that floor or ringing a bell. The door at this floor is also unlocked, so that by the turning of the ordinary knob, the door can be opened. Meantime all other doors are mechanically locked, so that no door can be opened until the cage is at that floor, and until the door at which the car has landed has been opened and closed. All the pushbuttons on other floors are inoperative until the door has once been opened and closed; then the pushbutton at any floor will call the car to that floor. The reason for requiring the door to be opened and closed before other floor pushbuttons are operative is so that a load consigned to a certain floor cannot be called away from that floor by any one desiring the elevator at any other floor.

DOUBLE-PLUNGER SIDEWALK HOIST.—The construction adopted for the sidewalk hoist of the Main Bldg. is unusual, and was made necessary by the requirement that the entire machinery be located above the cellar floor. This hoist is shown in Fig. 12. The cylinders are set (vertically) at the sides of the car, and the plungers are connected to the top of the car frame. This frame, with its deep upper cross-girder, was designed to be stiff enough to prevent distortion under an eccentric load on the car. The cylinders are worked from the 750-lb. supply.

The two other direct lifts, the coin lifts in the Old Bldg., are of the ordinary single-plunger form, the cylinder being located centrally below the lift shaft. These two machines operate on the 82-lb. supply system.

HOISTING CRANE.—This appliance is rather novel. It is similar to a swinging goose-neck crane in form, but the standard is a plunger working in a hydraulic cylinder; this arrangement supplies the hoisting movement and also permits of slueing the crane in a horizontal arc.

Fig. 13 is a drawing of this crane. The plunger has a snug bearing four feet in length in the

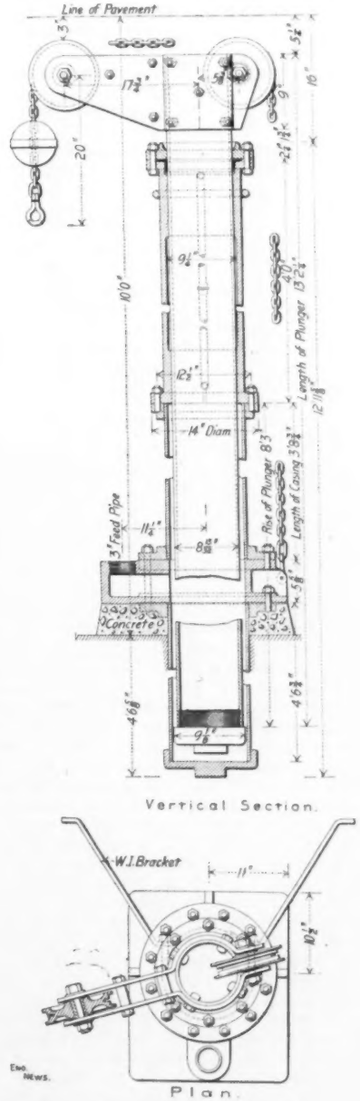


Fig. 13. Plunger Lift Goose-Neck Crane.

top end of the cylinder, and this bearing serves as guide for the crane. The hoisting chains pass over pulleys at the top of the crane and thence downward to a fastening on the base plate of the crane. In this way the hoist is virtually geared two to one, the rise of the hook being twice that of the plunger. The horizontal swing of the crane is limited by the cramping of the lifting chain to about 180°. Further details will be clear from the drawing. The cylinder takes water from the low-pressure, 82-lb. supply system.

CONCLUSION.—The above-described installation of elevators in the Prudential Bldgs. was placed in service in January, 1902. Previous to acceptance the main pressure system (750-lb.) was tested to 2,000 lbs. per sq. in., and the discharge system (82-lb.) to a pressure of 150 lbs. per sq. in. The contract price was about $300,000. Mr. Geo. B. Post, of New York, was the architect for the buildings, and V. J. Hedden & Sons were the general contractors. The Otis Elevator Co., Thos. E. Brown, Chief Engineer, was the contractor for the elevators. The writer, while in the employ of this company, designed and superintended the erection of the entire plant.

In regard to the "High Pressure" hydraulic elevator, as exemplified in this installation, it should be repeated that it represents the latest and most improved method of applying high pressures to hydraulic elevators, and that it places the high-pressure elevator, which under its proper conditions has great advantages over the low-pressure, on a firm and practical basis. The objectionable features of the pilot-valve shown in Fig. 1 have been removed by using water at low pressure to operate this valve, and the undecided differential change-valve has been abandoned. At the same time the complication and other disadvantages of the two operating pressures, as used in the "Two-Pressure" elevator, have been avoided, and a simple system secured by combining the cylinder discharge with the pilot-valve supply system.

The efficiency of the "High-Pressure" elevator with inverted plunger is about 70% in the form shown, and 80% when the weight of the lifting ropes is suitably counterbalanced by a chain or a hydraulic compensator. That the system is likely to be widely used is evidenced by the fact that the Metropolitan Life Insurance Co., of New York, has quite recently awarded a contract for 56 elevators of the type used in the Prudential Bldgs.

ELNATHAN SWEET.

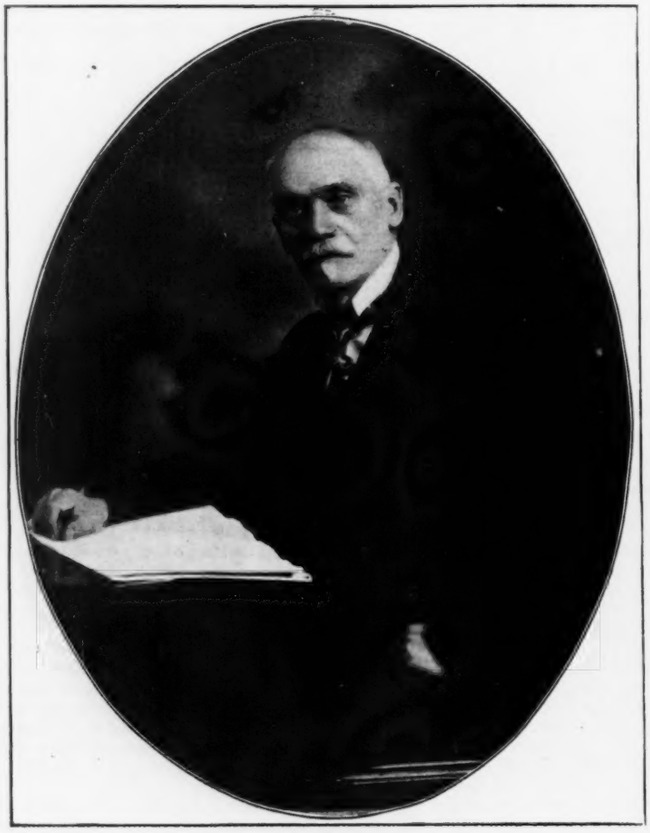
Elnathan Sweet, M. Am. Soc. C. E., late State Engineer and Surveyor of the State of New York, died suddenly of heart disease, on Jan. 26, at the Fort Orange Club, in Albany, N. Y.

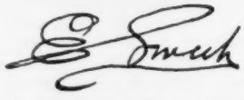
Mr. Sweet was descended from a well-known family of colonial Rhode Island; his great-great-grandfather, Elnathan Sweet 2d, at an early period removed to Dutchess Co., N. Y., and his great-grandfather, Elnathan 3d, settled about 1760 at Stephentown, Rensselaer Co., N. Y., where the grandfather and father of the late Elnathan Sweet were born. The father, Elnathan 5th, was born Nov. 22, 1796; married Chloe Cole; and died in June, 1879. He was a Baptist preacher, having charges at Adams and Cheshire, in Massachusetts, and for the last twenty years of his life he was located at Stephentown, N. Y.

Elnathan Sweet 6th, the youngest son of the clergyman, was born in Cheshire, Berkshire Co., Mass., Nov. 20, 1837; he received his earlier education in the public and private schools of Stephentown, N. Y., and Hancock, Mass., and in 1859 he graduated from Union College, having taken the civil engineering course at that institution. His first work in the field was performed as a deputy surveyor under Ward B. Burnett, Surveyor-General of Nebraska; but after a short time he returned to his home in New York, married, and was employed as an assistant engineer on various railway enterprises in the neighborhood of Stephentown. In 1864 he went to Franklin, Pa., to engage in the engineering development of oil wells, coal mines, etc., and he remained there until 1868, when he removed to Chicago. In 1869 Mr. Sweet was appointed Chief Engineer of the Rock Island & St. Louis Ry., now part of the Chicago, Burlington & Quincy system, and he constructed 230 miles of this road in about twelve months. In 1871 he was made Superintendent as well as Chief Engineer; at this same time he was Consulting Engineer for the Rockford Central and the Cairo & St. Louis railways.

In 1872 he formed a partnership with James R. Young, of Chicago, under the firm name of E. Sweet, Jr., & Co., to engage in railway construction, and he continued in this business until 1875. This firm built a section of the Northern Pacific Railway, extending from the Red River of the North, across Dakota, to the Missouri River; it also constructed several bridges in Chicago and a part of the West Point tunnel on what is now the West Shore Ry.

In 1875, Mr. Sweet was appointed by Gov. Tilden, of New York, as expert engineer to the commission selected to investigate abuses and alleged frauds in connection with the New York State canals. He was engaged in this difficult and responsible work until 1876, when he was appointed





a Division Engineer on the canals and held this position until 1880. Mr. Sweet then resigned this post, and, until 1883, he was again engaged in railway construction with his former partner, Mr. James R. Young; they built about 50 miles of the West Shore & Buffalo Railway, finished the West Point tunnel, and constructed a part of the New York, Susquehanna & Western Ry.

In 1883, Mr. Sweet was nominated for the office of State Engineer on the Democratic ticket, and was elected. In 1885 he was re-elected to the same office, serving in all four years. During his administration, he made experiments on a large scale to determine the laws governing the resistance of vessels propelled in narrow waterways, as affecting the proper design and probable capacity and economy of canals. The results, including some previous experiments made while he was Division Engineer, were published in the Transactions of the American Society of Civil Engineers in 1879. As State Engineer Mr. Sweet made strenuous efforts to restore to the engineering department the control of all engineering matters in which the state was interested, instead of delegating many of these to independent commissions or to other departments of the state government, as had been the previous custom. In this he was successful, and to his labors the present office of State Engineer is mainly indebted for its increased powers.

Upon retiring from office in 1887, Mr. Sweet resumed the practice of his profession of civil and consulting engineer. He was President and Trustee of the Hilton Bridge Construction Co., and was at one time Receiver of the Lebanon Springs R. R. Co. He introduced many improvements in the design of movable bridges and bridges of long span; especially in the combination of the arch and cantilever, as shown in his design for the bridge connecting Capitol and Arbor hills, in Albany.

Mr. Sweet's paper on "The Radical Enlargement of the Erie Canal," read at the annual convention of the American Society of Civil Engineers in 1884, was the first formal project for the construction of a deep waterway from the Lakes to the Hudson. In this paper Mr. Sweet urged that thorough surveys be made for such a canal; and the final outcome of the paper and the discussion upon it has been the expenditure of nearly a million dollars by the United States and the State of New York, upon such surveys. In the development of this project in recent years Mr. Sweet took an active interest. It is noteworthy that in the discussion before the American Society of Civil Engineers two years ago upon this subject, Mr. Sweet favored the project for a 21-ft. waterway in preference to the 12-ft. waterway, which is now before the New York Legislature, declaring that "No waterway built to connect the Lakes and the ocean can hope to secure great commercial importance unless it can accommodate the largest vessels navigating the Great Lakes."

Mr. Sweet's ability and his services in the development of the canal system received recognition, two years ago, when he was made President of the Advisory Commission appointed to aid the State Engineer in the conduct of the surveys for the 1,000-ton barge canal.

Mr. Sweet's most recent and most important public service was as a member of the New York Water Storage Commission. The report of this commission was abstracted in our last issue. It is noteworthy as the first formal proposition to undertake in the United States the work of river regulation which has been developed to such an extent in Europe. To carry out the recommendations of this commission Mr. Sweet drafted a bill for submission to the legislature, and he was engaged in this work up to the very evening when his death occurred. As will be seen by reference to our abstract of the commission's report, the purpose of the commission as embodied by Mr. Sweet in the bill was to conserve the water supply of the state for the public benefit, and the belief was expressed that such a policy would more profoundly influence the prosperity of the commonwealth, than any public enterprise that could be undertaken.

Since 1875 Mr. Sweet has been a resident of Albany, and he has been prominent in municipal af-

fairs. He was a trustee of the sinking fund and a member of the finance board of the city from 1889 to 1892, and in July, 1896, was reappointed to these positions. He was a member of the Water Board from 1892 to 1894.

Mr. Sweet was elected a member of the American Society of Civil Engineers Nov. 6, 1878; he was also a member of the University Club of New York, and the Fort Orange Club of Albany. He was married Nov. 20, 1860, to Marion Rose, daughter of Jonathan Rose, of Stephentown, N. Y., and his wife, one son and six daughters survive him.

BRIQUETTING PETROLEUM under the Granville patents is to be undertaken on a large scale, it is said. A plant having a capacity of 1,000 tons a day is being built at Port Arthur, Texas, and another plant of equal capacity is being built at San Raphael, San Francisco. The petroleum is "compressed" to several times its normal density with the loss of a small volume of gas during solidification. The briquettes burn with intense heating effect, burning from the top down. Being naturally absorbent of water, the briquettes are provided with an anhydrous coating.

A DRAINAGE SYSTEM has recently been completed for reclaiming the swamp lands of the Green River bottom in Lee, Whitehead and Bureau counties, Illinois. Considerable areas have already been reclaimed, and the land is now said to be valued at $75 to $90 an acre. There are nearly 50 drainage ditches of varying size, about a mile apart, and these connect with a canal leading to the pumping station at the Meredocia swamp, where the water is raised and discharged into the Mississippi River, the level of which is above that of the swamp. The work has been in progress for some 15 years, and the total cost is said to have been $2,500,000.

FALL OF A HIGHWAY BRIDGE AT TRENTON, N. J.

In our issue of Dec. 25, 1902, we gave a brief note of the failure of a new highway bridge at Trenton, N. J. The structure was about to be turned over to the county, and the erectors were still at work on it when it gave way under only its dead weight. We have just been favored by the Berlin Construction Co., of Berlin, Conn., the builders of the bridge, with the report of the Bridge Committee to the Board of Freeholders; an investigation was instituted by them immediately after the fall, and we here reprint, in part, the conclusions of the committee as given in their report.

The bridge was a pony Pratt truss bridge of 60-ft. span; it had a 36-ft. roadway and two sidewalks. The floor was designed to carry two lines of electric railway and a 12-ton road roller. The trusses had riveted connections and the floor beams were riveted into the posts. The floor of the roadway was composed of concrete and expanded metal construction between the beams, surfaced with macadam. The bridge was being hurried to completion so as to be ready for acceptance at a certain meeting of the Board of Freeholders, although the contract time had not nearly expired. It appears that almost the last work required was to finish riveting up some of the main joints.

The report of the Freeholders' committee makes the following statement in regard to the manner in which the accident occurred:

With but six hours' work required to complete this contract, all concrete and macadam being in place, the truss on the down stream side of the bridge was disabled by the failure of the main diagonal connection to the upper chord at the batter end post; the truss dropped in the creek, carrying with it the floor connected thereto and wrenching the upstream truss out of shape by the canting of the floor beams, which were rigidly riveted to it. This (upstream) truss, though carrying about three-quarters of the total load of the bridge and badly wrenched out of shape, withstood the shock and showed no evidence of any signs of failure.

Upon investigation of the cause of the accident it was evident that the failure was due to giving away at the above-mentioned connection. Close inspection of this connection established clearly that there was but one bolt in place at the time of the failure. As there had been since the erection of the truss ten bolts in this connection, the investigation was directed to establishing just how these bolts had been removed. It was found that a regular bridgeman and a helper were fitting up this connection shortly before the accident. During the absence of the bridgeman for a few minutes the helper, according to his own statement, removal all but one of the bolts from this connection, which, of course, caused the failure of the truss through shearing of a single bolt.

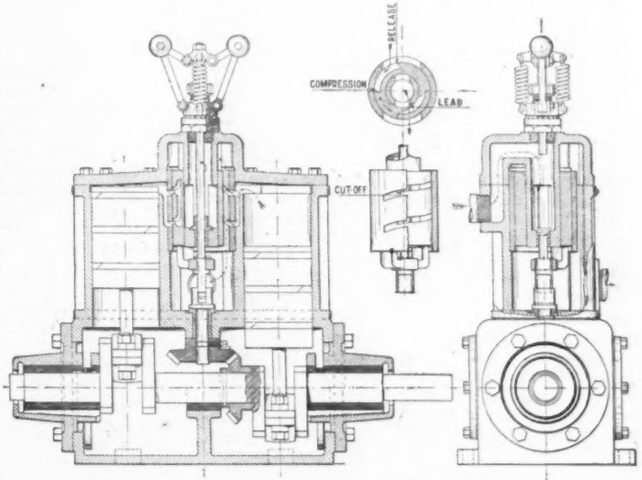
After the failure the bridge company immediately telegraphed orders for the construction of two new trusses, which were received at the site within five days after the accident. The collapsed structure was removed, the new structure erected and riveted complete ready for the concrete and macadam roadway within the remarkably short time of two weeks from the hour of collapse of the first structure and without any allowance of time for bad weather.

A STEAM ENGINE WITH A SINGLE ROTARY VALVE.

A new steam engine of the high speed enclosed type, which is just being placed on the market, has as its essential feature a novel arrangement of ports and valve which secures some of the results of the four-valve engine, with the use of but a single valve. This arrangement, which has led the makers to call the engine a "four-ported engine," is thought to enable economy and simplicity to be obtained in small engines, so that these will be comparable in economy with much larger engines of present types, while yet being simple as small slide-valve engines or even simpler. The engine is built by W. J. Francke, of New Brunswick, N. J., and its sale is in the hands of Mr. T. C. Maxfield, 120 Liberty St., New York, to whom we are indebted for the following description and the accompanying cut of the engine.

The Francke engine is a vertical engine with two cylinders set side by side. Both pistons are single acting, and are, therefore, built as trunk pistons, and the connecting rods are fastened to them directly by a pin. The pistons, which thus act as crossheads, are made very long in order to properly provide for the lateral pressure from the rods. The valve, which serves both cylinders, is located between them, and takes the form of a vertical hollow cylinder mounted upon and driven by a shaft which is bevel-geared to the crank-shaft. The upper bearing of the valve-shaft is formed in the top of the engine casing, and just above this bearing the shaft carries a centrifugal ball governor. The arrangement of these parts will be readily apparent from the accompanying cut, which shows two vertical sections through the engine.

The only parts of the engine that call for explanation are the valve and its related parts. As already stated, the valve is tube-shaped, with its axis vertical. It rotates in a cylindrical bushing which is inserted into the chamber between the steam cylinders; this bushing has ports cut in it on opposite sides, communicating respectively with the interior of the two steam cylinders. The valve itself also has ports cut in it, adapted to register at the proper period with the ports in the bushing. The interior of the valve-tube fits over a prolongation downward from the top of the engine casing. This prolongation has a hollow, or steam chamber formed within it, which communicates with the live steam pipe; from this chamber suitable steam supply ports open outward.



SECTIONAL VIEWS OF FRANCKE ROTARY-VALVE ENGINE.
Built by W. J. Francke, New Brunswick, N. J.

The remainder of the valve-chamber is utilized as an exhaust steam space. It will be seen from the drawings that the tubular valve itself is balanced longitudinally, since both its ends are exposed to the exhaust steam pressure. The valve has two ports, an admission port and an exhaust port, which serve for both cylinders by registering alternately with the two ports in the bushing surrounding the valve. The horizontal section of the valve, also shown in the cut, makes this clear. The exhaust port is a longitudinal depression in the outer surface of the valve tube, and, when in register with either of the ports in the bushing, it discharges the steam both upward and downward into the exhaust space of the valve-chamber, whence the steam passes into the exhaust pipe. The admission port in the valve is cut entirely through the tube, so that it may connect the opening in the steam chamber with the port in the bushing. A partial elevation of the valve and bushing, shown in our cut, exhibits the shape of the port in the bushing and the admission port in the valve. These are made double (i. e., there are two ports vertically below each other) and are helical, or inclined to the axis of the tube. This inclination is for the purpose of governing the point of cut-off, as will be explained.

The governor, seated on top of the engine casing and rotated by the vertical valve-shaft, is of the ordinary centrifugal ball type, and is adapted to raise the valve-shaft when the speed of the engine exceeds the proper limits. The upper part of the valve-shaft, on which the valve is carried, is so connected to the lower part of the shaft that it can move a short distance up or down. The governor, as mentioned, is adapted to raise or lower this portion of the shaft, and thereby the valve, when the speed of the engine changes. Now as the cutting-off edge of the admission port is inclined to the horizontal, its position with respect to the port in the bushing changes as the valve is moved up or down; when the valve is moved upward, the cut-off occurs earlier, while when it is moved downward, the cut-off occurs later in the stroke. The limit to the length of cut-off is fixed by the total circumferential length of the port.

It is to be noted that the point of admission, being determined by vertical edges of the ports in valve and bushing, is not affected by shifting the valve axially. It is therefore possible to set the valve once for all to give the lead most suited to any particular engine; the action of the governor during operation of the engine will not change the lead, but will simply shift the point of cut-off. For a similar reason the action of the exhaust port always remains the same, no matter how the governor shifts the valve, so that release and compression always begin at the same points of the stroke.

The engine is lubricated by utilizing the crank-chamber as an oil reservoir. The crank-shaft bearings have oiling rings within this chamber, while the pistons and the bevel gears driving the valve-shaft are lubricated by the oil splashed about the chamber by the cranks. The steam pipe can be fitted with a lubricator to oil the valve.

It is claimed for the engine that high economy can be secured in all sizes and at all loads. Its simplicity and its high speed, due to the absence of piston rod and crosshead and the possibility of determining the fixed compression point so as to secure the proper balancing compression, are stated to be its special advantages. As will be seen from the drawing, the upper bearing of the valve-shaft is exposed to live steam, but this is the only stuffing box required in the entire engine.

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ADVERTISING RATES: 20 *cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.*

The number of recent train accidents in which fire has followed the wreck recalls the crusade against the deadly car stove which was started by the White River holocaust of 1887; and the collision in the Park Ave. tunnel, which came soon after. The extensive introduction of steam heat from the locomotive was undoubtedly brought about by these two disasters, and it is probable that hundreds have been saved from a death of torture by the reform then made, together with the accompanying substitution of Pintsch gas in place of oil lamps.

The frequency of fire following collisions and derailments of late suggests that the reform has never been made complete, although it is fair to say that there is always the possibility of fire being set in a bad wreck by coals from the locomotive firebox. The fact that the majority of passenger cars used in service on American railways have been heated by steam for many years now leaves the continued use of car stoves of any sort without excuse. Nearly a dozen years ago the American Railway Association adopted as its standard method of heating passenger trains the use of steam from the locomotive boiler, and by implication condemned the car stove in any form. It is time that the railways represented in this association undertook to live up to this resolution.

A new source of danger in train accidents was made evident in the Tucson collision, of Jan. 28, on the Southern Pacific. Both locomotives burned fuel oil and the force of the collision broke open the oil tanks and the oil ran down the gutter beside the track, was set on fire, and converted the whole wreck almost immediately into a mass of flame. Any railway officer would apprehend at once the danger of hauling an oil tank car in a passenger train; but a tender tank filled with oil may be quite as fatal a companion in a wreck. In view of the complaints made of oil in passenger service on account of the injury to the varnish of cars and the general dirtiness, together with the danger now apparent in case of accident, it seems open to question at least whether it is wise to burn oil on passenger locomotives.

The several letters which we have recently published reporting the disintegration of newly-laid concrete by covering it with manure should not only serve as a warning to contractors and engineers against this rather common plan of protecting concrete laid in freezing weather, but should set some of the investigators in engineering laboratories at work to determine the cause of this peculiar action. Evidently there are some things about the behavior of cement concerning which the wisest are still in ignorance. Another illustration of this fact was brought forward at the last meeting of the Boston Society of Civil Engineers, reported on another page of this issue. Mr. J. W. Rollins, Jr., reported the entire failure of several brands of cement to set under water, for no other reason apparently than that the water was very slightly contaminated by the waste from pulp mills.

Elsewhere in this issue we give a report of the annual meeting of the Canadian Society of Civil Engineers. It will, no doubt, surprise many of our readers on this side of the boundary to learn that this Society has passed the thousand mark in its membership. A noteworthy fact brought forward at the meeting is that the Society is about to make a vigorous effort to include among its members not only "civil" engineers, in the American sense of the term, but mining, mechanical and electrical engineers. While at present there is strong opposition to dropping the word "Civil" from the title of the Society, as an aid to such a broadening of its field, there is a very pronounced feeling that something should be done to attract engineers from other branches of the profession to membership in the Society.

It was urged that to drop the word "Civil" from the Society's title would cause members of various engine-driving crafts to apply for membership in the Society; but it is hardly likely that this objection influenced many members. Neither is it likely that the general public would confuse a professional society with a trade organization, merely because the adjective "civil" were dropped from its name.

Indeed, we question whether the general public opinion need be considered at all in this matter. How many of this general public even know what a Civil Engineer is?

It is admitted that one large library will far better serve engineers of the four professions than would four small libraries for as many subdivided societies; and the same is true of the Society House and other necessities. But all this is of even less importance than the strength that comes from unity of purpose and action.

If the Canadian Society can bring into one strong organization the members of the Civil, Mechanical, Mining and Electrical branches of the profession, it may furnish a valuable object lesson to members of engineering societies in the United States.

SOME LESSONS OF RECENT COLLISIONS.

We briefly reported last week the circumstances of the disastrous rear collision on the Central Railroad of New Jersey, which resulted in the death of 23 persons. Later information shows that abundant warning was given to the engineer of the express which crashed into the rear of the suburban train. He had, in fact, the warnings of both the block system and the train order system. The suburban train was protected first by a home signal 1,500 ft. to half a mile behind it, according to various reports; and second by a distant signal at the beginning of the previous block, 3,000 ft. further back. Still further back at Cranford, 3 miles from the scene of collision, a train order was sent to the express engineer, notifying him that the suburban train would run on the track ahead of him. Whether this order reached Cranford in time to set the train order signal is a matter on which reports differ.

The suburban train, moreover, took the same precautions to protect its rear that would have been taken in the absence of the block system. The rear flagman went back and is said to have put down two torpedoes before returning to his train, which had just started when it was struck by the express. Besides this a flagman at a grade crossing, who knew the suburban train was a short distance ahead, signaled to the express engineer with his lantern.

All these warnings failed to stop the express train. Its engineer, who received fatal injuries in the wreck, made an ante-mortem statement in which he is reported to have said that he saw the green (caution) signal but "thought it would turn to white." He did not shut off steam, nor did he watch for the lights at the next signal but got down to fix the injector and while so engaged passed the home signal, and when he again looked ahead he was close upon the rear of the suburban train.

If it is true that the engineer saw the green signal and neglected to at once bring his train under control, or at least to watch diligently for the indication of the home signal to be ready to stop before reaching it, then a sermon ought to be preached to every engine-runner, and to every railway officer who has to do with the disciplining of engine-runners, upon the uses—and misuses—of the distant signal.

We prefer, however, to go at once to the broader questions which this disaster has set men asking. If accidents like this occur under the block system, we hear it said, where is the boasted safety in railway travel that was to be secured by it? The ultra-conservative railway manager—and particularly the ultra-conservative director who holds the purse strings—declares that he will not spend great sums to install a system under which such acicdents as this are still possible. The advocate of the block system cannot fall back on the claim that this is an isolated and exceptional case, either; for it is most unfortunately true that a long list of collisions have occurred in this country on trains running under the block system and chargeable in nearly all cases to the same cause as the Westfield collision, viz., failure of the engineer to obey the signals set against him.

In the face of these facts, we who have advocated the block system, in season and out of season, for so many years, as the only road to safety in the movement of trains would be compelled to modify some of our claims for it save for one thing: That is the remarkable freedom from collisions of trains on European railways and particularly of those of Great Britain, practically all of which are operated under the block system. The figures must be familiar to our readers. It will be remembered that in 1901 not a single passenger on the railways of Great Britain lost his life in a train accident. The number of passenger journeys in Great Britain is not very far below that of the United States; the traffic is much more crowded, train speeds average as high or higher; and fogs are much more prevalent.

Under these conditions English railway trains are moved with almost absolute freedom from collisions, and the puzzling question is why cannot we in the United States do as well or anywhere near as well? Why does not the block system here bring the same immunity from collisions that it does there? Why should American engine-runners repeatedly and frequently run past danger signals while in England such a thing is of the rarest occurrence?

We believe the best answer to this question is found in a comparison of the way the block system has been used here and abroad. In England, every engine-runner has been brought up under the block system. Every mile that he has ever moved an engine has been under the guidance of fixed signals. To watch for their indication and render implicit obedience to it is a fixed habit. How different is the case of the American locomotive engineer. If he is a man of much experience, his early training must have been under the train order system and probably half the train-

men in service here to-day have had no experience with anything else. The total mileage equipped with any sort of block signals, according to the figures in our issue of Aug. 21 last, is only 25,000 miles, only one-eighth of the total mileage of the United States.

A large proportion of the block signals are concentrated on the much-used sections of track near cities. Thus many engineers who run under the block system for part of their trip run under train orders for another part. On this very road where this last fatal accident occurred, if we mistake not, the block signals extend only as far as Bound Brook. Why should we expect an engine-runner to regard obedience to the fixed signals as his one duty, surpassing all others, when a large part of his run is made without their protection at all? We may question, too, whether there is among railway officials generally that universal recognition of the importance of the block system and of implicit obedience to it in the movement of trains, that must exist if the best results are to be secured by it. Certainly if the contrary were the case—if all our railway officers regarded the block system as a necessity to safe train movement, its introduction would proceed much faster. The real fact is that among the subordinate officials of our railway systems one finds a vast amount of conservatisms, and even though this conservatism finally falls into a minority and new improvements are introduced, the conservative men "are of the same opinion still." We heard of a New England railway not long ago, which has a fine equipment of block signals but which moves freight trains over its line part of the time at least without regard to the signals. Such discipline as this, it is manifest, is calculated to destroy an engine-runner's respect for the block system and lay the foundation for just such fatal disobedience to it as that which cost 23 lives on the Central Railroad of New Jersey last week.

If the above explanation is correct, then the real lesson of the Westfield collision is that the introduction of the block system should be hastened. The railway officer who argues that these collisions under the block system should delay its adoption is taking a narrow view of the matter. The thing to do is to extend the block system, and to discipline every member of the operating force to regard its authority as supreme and obedience to its indications as the paramount duty.

If anyone is inclined to take the contrary view and to claim that the old system of operating trains by train orders is after all about as safe as the block system, we would point him to the holocaust on the Southern Pacific, near Tucson, Arizona, which occurred only eight hours after the Westfield collision. A telegraph operator had two meeting orders for a fast express train and forgot to deliver one of them and the result was a head collision and conflagration following in which 20 persons lost their lives. We would recall the butting collision at Wanstead on the Grand Trunk, and the rear collision on the Southern Pacific in California, in December, in each of which some 25 lives were lost. We would add to this the long list of collisions reported weekly and daily, so many in fact that only a small proportion of them ever finds mention in the newspapers. We would turn to the last official record of accidents for the three months ending Oct. 1, 1902, and show the defender of the train order system that in this short space of time there were on the railways of the United States 1,434 collisions in which 148 persons were killed and 1,539 were injured. We would add for the benefit of the would-be economist who argues that his road is too poor to afford the block system that these collisions involved a direct property loss of over a million and a quarter dollars; and this loss would be fully trebled if a moderate compensation were allowed to each injured person and the heirs of those killed.

No intelligent man who gives any sort of study to the question can fail to conclude that the block system, even though it fail at times, is incomparably safer than the old train order system for moving trains; and whoever takes such isolated cases as the Westfield disaster for proof to the contrary is making a grave mistake.

LETTERS TO THE EDITOR.

"Rotting" of a Concrete Sidewalk by Manure.

Sir: In Engineering News of January 29, 1903, appears an article on the question, "Does Manure Rot Concrete?" During November, 1901, I had supervision over some 300 ft. of concrete walk that was being built by a local contractor. The walk was finished a few hours before a heavy sleet and snow storm. The average temperature during the building of the walk was a little above freezing. The top coat seemed to be fully set before the manure was put on as a protection against a probable freeze. The manure was left on about a month, and when first removed the only injury seemed to be many places badly discolored. After a short time the top began crumbling and breaking loose from the foundation, and by warm weather was entirely gone. The foundation in a few places showed signs of a slight disintegration. Other cases that have come under my observation lead me to believe that manure has no effect upon concrete that has become fully set.

Respectfully yours,

Leon D. Conkling, City Engineer.

Elmira, N. Y., Jan. 30, 1903.

What Shall Be Done for Absent-Minded Locomotive Engineers?

Sir: In view of the two railroad accidents (for such they really were) of this week, and others within painful recollection, it would seem that something must soon be done on metaphysical lines for those in charge of transportation and its vehicles. Habit is an untrustworthy qualification in any avocation requiring the exercise of the mental faculties, and mute mechanisms in the landscape are to occupied minds mere suggestions of what is going on in the external world. Is it too much to expect that with the advent of our Twentieth Century trains of various designations, there will be an improvement in the essentials of operation that obtained two-thirds of a century ago when Sidney Smith wrote the following in a letter on railways:

Railroad traveling is a delightful improvement of human life. Man is becoming a bird: he can fly longer and quicker than a solan goose. The mamma rushes sixty miles in two hours to the aching finger of her conjugating and declining grammar boy. The early Scotchman scratches himself in the morning mists of the North, and has porridge in Piccadilly before the setting sun. The Puseyite priest, after a rush of one hundred miles, appears with his little volume of nonsense at the breakfast of his bookseller. Everything is near, everything is immediate—time, distance and delay are abolished. But, though charming and fascinating as all this is, we must not shut our eyes to the price we shall pay for it. There will be, every three or four years some dreadful massacre—whole trains will be hurled down a precipice, and two or three hundred persons will be killed on the spot. There will be every now and then a great combustion of human bodies, as there has been at Paris; then all the newspapers up in arms—a thousand regulations forgotten as soon as the directors dare—loud scream of the velocity whistle, monopoly locks and bolts, as before.

Yours respectfully, Mercy.

Scranton, Pa., Jan. 30, 1903.

The Compensation of Engineers.

Sir: Judging from the number of letters recently published in Engineering News on the above subject, there seems to be a general awakening to the fact that the profession is being underpaid.

Examples are not difficult to find. In fact, I venture to say that 95% of the profession are not receiving salaries commensurate with their responsibilities.

One example that has recently come to my notice deserves special mention. I understand that there has been a little difficulty in filling the position of assistant engineer in the office of the State Engineer of New York, and as a result non-residents are being permitted to take the examination for that position in the hope of securing more applicants. The difficulty lies not so much in the insufficiency of engineers in the state as in the small inducements offered. The candidate must have had at least four years' experience in responsible positions, and after passing a very rigid examination covering all the branches of engineering, if the fortunate (?) candidate secures an appointment, he is given the munificent compensation of $5 a day, for days worked—no pay for Sunday or holidays.

Bricklayers after serving an apprenticeship of a few months are paid $5.20 a day for eight hours, and double pay for overtime. Engineers in charge of work are offered $5 for about 18 hours' work and nothing for overtime. As far as compensation per hour is concerned, the state pays their assistant engineers about on the same basis as the laborer with the pick and shovel. And yet they wonder why they do not have more applicants for the position. The remedy lies not so much in increasing the field of competitors as it does in offering sufficient inducement for the men to seek the position. Steady employment at $200 per month would hardly be excessive for a position with such responsibilities. When the Empire State, the richest in the country, sets such a munificent example of engineering compensation, what can we expect from private corporations whose business it is to engage employees at the lowest possible figure.

The fault lies largely with the engineers themselves in valuing their services so cheaply. Their compensation has reached its low notch. When in almost every issue of a technical journal we see advertisements calling for experienced engineers for responsible positions and offering "living wages," it is about time something was done to alleviate conditions.

It is well to talk of professional ethics, but when one is forced to work for living wages (and not always able to get that) I think it is about time that the men organized and demanded their due.

I notice some of your correspondents have tried to draw a comparison between the compensation of doctors and engineers. Such a comparison is of little value. An engineer is a professional man in the sense that a high degree of scientific and technical knowledge is required of him. His duties are of a commercial nature. An engineer in charge of a $3,000,000 job would probably be getting $150 per month at most. A man managing that amount of business for a commercial house would probably be getting at least $500 per month. Stenographers, clerks, any of the skilled laborers; in fact, any competent person in other occupations almost invariably are securing better pay than engineers. Under such conditions it is not surprising that the subject is of interest to engineers; the surprise lies in the fact that so many young men are going into this line, ignorant of its actual conditions, and that nothing is done to remedy these conditions.

I. V. W.

New York, Jan. 28, 1903.

The Electric Smelting of Iron Ore.

Sir: A clipping has been sent me from your issue of Jan. 8 upon "An Attempted Defence of the Electric Smelting of Iron Ores." I desire to point out certain errors in your argument, and to substantiate some of Mr. Rossi's statements and show you that they are worthy of something more than ridicule.

You take exception first to Rossi's statement that a blast furnace pays $4.50 a ton for its ore while "the electric furnace competitor will develop new mines by a marvelous system that will enable them to mine, haul and deliver ore for 75 cts. a ton at the furnace mouth."

Mr. Rossi's statement is correct, as you can readily inform yourself, and I can see no cause for amusement in his statement. Lake ores of a given grade have sold during the past season at lake ports at $4.25 per ton, the freight rate to Pittsburg and Eastern points raise that cost to 9 cts. a unit. Adirondack magnetite is being mined for 50 cts. a ton. Rossi's paper, as I remember it, based his figures upon a hypothetical plant that would be so situated that water power and ore would be near together, which would eliminate the items of hauling and delivering. "It is also worth noting that 'carbon' is assumed to be only about half as costly as coke." This is not an assumption, it is a fact, as you can yourself determine by ascertaining the value of charcoal breeze.

As to the value of a horse-power year which is the equivalent of 8,760 HP. hours, you ridicule Mr. Rossi's assumption of $10 as being a fair value for it. In contracts that have been offered me by reputable, responsible people, ready to deliver the power, the prices have been $10 per HP. year at the switchboard in one case, and $8 at the water-wheel shaft in another case. If you or a competent engineer at your command will figure up the cost of a HP. year generated by a compound condensing engine of, say, 5,000 KW. capacity, in a favorable location for cheap fuel, your nerves will receive another shock, and should you care to continue your investigations into the domain of large gas engines fed by gas from by-product coke ovens, or even from gas producers, you will have a case of nervous prostration.

You say, further, that a 350-ton blast furnace outfit will cost $1,000,000. Granted. You say, further, that it would require 60,000 HP. to produce the same metal electrically. If the truth interests you, I will show you right here in Lockport how less than 10,000 HP. will do the 350 tons. And, further, I will prove to your satisfaction that instead of $1,000,000 being the investment in plant required, as in the case of the blast furnace, an investment of $500,000, or one-half your investment, will do the work.

I will further prove to you that I can mine, concentrate, freight and smelt electrically and produce steel melting stock for less than any blast furnace can produce pig iron; that when the blast furnace costs (ore, fuel and labor) are down, mine will be down, and when their costs are up, mine will be up. My fixed charges are but half and my costs of maintenance and operating expenses much less.

Very truly, Marcus Ruthenburg.

Lockport, N. Y., Jan. 26, 1903.

(We will confine ourselves to comment on two points raised in the above letter:

(1) Very likely charcoal breeze can be purchased in small quantities at $1.25 per ton; but if purchased in the quantities necessary for iron smelting on a large scale, the price would at once advance to that of charcoal. According to Mr. Rossi's own figures, it takes about one-third as much charcoal to make a ton of iron in the electric furnace as it does of coke to make a ton of iron in the blast furnace.

(2) Mr. Rossi's own figures of efficiency for the

electric process of ore reduction were 200 E. HP. per ton of iron produced per day. Then for an output of 350 tons per day $350 \times 200 = 70{,}000$ HP. would be required. We said 60,000 HP.; allowing something for increase of efficiency in a plant of large size. Mr. Ruthenburg claims to be able to do it with 10,000 HP.; but he must remember that a known definite quantity of heat is required to separate the oxygen from the iron in a pound of iron ore, and that the heat which a horse-power of electric energy can produce in a given time is also as definite a quantity as the weight of a quart of water.—Ed.)

The Merits and Demerits of Various Types of Joist Hangers.

Sir: I note the article by F. E. Kidder in your issue of Jan. 15, evidently written in the interests of the Duplex Joist Hangers. I think that Mr. Kidder has taken for granted some statements written in the catalogue of these people without proper investigation, and would ask that before he condemns other types of hangers and stirrups he should look into this matter a little more carefully. We would respectfully call his attention to a failure in actual service of a Duplex hanger used in the Sears, Roebuck Building in this city, whereby a team was precipitated into the basement and considerable damage done. We think there is no question that a steel hanger is much superior to a hanger made of so-called malleable iron, which may or may not be properly annealed, and is apt to contain flaws which cannot be detected on the surface. Comparative tests made by any one concern for the sake of showing up the merits of their particular product over those of other manufacturers, even when the experiment is conducted by an engineer in the employ of this particular concern, should not be accepted as showing the true merits of the case.

Yours very truly,
E. Haupt.

184 La Salle St., Chicago, Jan. 17, 1903.

(Proof of the above letter was submitted to Mr. Kidder, and we append his reply as follows.—Ed.)

Sir: I desire to take exception to the following statements in Mr. Haupt's letter. First, that my communication published in the issue of Jan. 15, "was evidently written in the interest of the Duplex joist hangers"; second, "that there is no question that a steel hanger is much superior to a hanger made of so-called malleable iron, which may or may not be properly annealed," etc., and third, to the general implication that the tests described in the catalogues of the Duplex Hanger Co. are misleading.

My communication was not written in the interest of the Duplex hangers, but for the express purpose of calling attention to the fact that the carrying capacity of steel hangers of the stirrup type *cannot be measured by the tensile strength of the steel*, as it has been clearly shown that single stirrups fail by bending long before the breaking strength of the steel is reached. Even disregarding all tests, the accident in the Minneapolis building proves this statement, and any engineer should be able to see, when once his attention is called to it, that this must be true, for the top of a stirrup, as ordinarily made, cannot offer much resistance to bending.

The manufacturers of steel stirrups lay great stress on the high tensile strength of the material used, but as a matter of fact this has little to do with the carrying capacity of the stirrup.

I remember the time when it was quite a common practice to proportion wrought-iron pins simply by their resistance to shearing, without regard to the bending moment, and it looks as though the bending moment was still overlooked in the use of steel stirrups.

Steel is unquestionably a more reliable material than malleable iron; and if it were practicable to make a steel stirrup that would offer sufficient resistance to bending, it would undoubtedly be preferable to one made of annealed cast iron; but a stirrup which lays on top of a beam that must be covered by a floor cannot have very much depth of flange.

The National hanger is designed on the right principle, but the practical conditions do not permit a sufficient height of flange on top. For the same weight of metal this should be the strongest stirrup made, but even this hanger has not shown a carrying capacity equal to that of the Duplex hangers.

I believe that the tendency with all of the manufacturers of steel stirrups is to make their hangers too light. The Minneapolis case is the only one that has come to my attention where a steel hanger has failed in actual use, but it is perhaps as much through good luck as anything else that more failures have not occurred.

I do not by any means condemn hangers of the stirrup type; all I desired was to call attention to the danger of overlooking their tendency to fail by bending.

Regarding the reports of tests published by the Duplex Hanger Co., I will merely say that I have seen the original reports; that they agree with the printed reports, and that I should hesitate a long time before questioning the integrity of the engineers who conducted them and signed the reports.

On account of my "Hand Book" I have for many years given especial attention to this subject, and have kept pretty well posted in regard to it. For several years I was somewhat afraid of the Duplex Hangers, on account of their being cast, but they have stood such severe tests and so many thousands of them have been used without failure that I do not now hesitate to endorse them, notwithstanding the single case of failure to which Mr. Haupt refers.

I also wish to correct two errors in my communication published in your issue of Jan. 15: First, the Van Dorn hanger, shown by Fig. 3, commenced to straighten out under a load of 13,300 lbs. and failed at a load of 18,750 lbs.; second, the Duplex hanger tested at the Massachusetts Institute of Technology was a No. 35, which is supposed to have only half the strength of the No. 75 hanger.

Very respectfully, F. E. Kidder.

628 Fourteenth St., Denver, Colo., Jan. 28, 1903.

Shipping Dynamite.—A Correction.

Sir: We note in your issue of Jan. 22 an article, entitled "The Beginning of the End of Dynamite." As the writer has evidently endeavored to write truthfully as far as he knows regarding high explosives or dynamite, I would suggest that he improve his education a little further with a view to writing the truth. For instance, from what source does the information come that the N. Y., N. H. & Hartford R. R. does not handle dynamite?

We have been shipping dynamite over this road for several years, and it seems it is necessary for us to go to Engineering News to find out that they do not accept it.

I will say that the Climax Powder Mfg. Co. have experienced no trouble in making any shipments of dynamite over the New York, New Haven & Hartford R. R.

Yours very truly, The Climax Powder Mfg. Co.
Per Wm. A. Battle, Agent.

434 Park Row Bldg., New York, Jan. 29, 1903.

(The statement made in our issue of Jan. 22 that dynamite is not received for shipment on either the Delaware, Lackawanna & Western R. R. or the New York, New Haven & Hartford R. R. appears to have been in error so far as one of these roads is concerned. The error arose from the fact that the N. Y., N. H. & H. R. R. does not receive dynamite unreservedly, as appears from the following letter wherein it will be seen that dynamite which is to be transhipped to some other line will not be received except by special agreement, and then only when packed as prescribed. The following letter gives the conditions under which dynamite is received for shipment by the N. Y., N. H. & H. R. R. Co.—Ed.)

Sir: Replying to your letter of Jan. 30, relative to our acceptance of a shipment of dynamite, would state we accept these shipments daily excepting on Saturdays or a day preceding a holiday, for all stations on the New York, New Haven & Hartford R. R. Shipments of dynamite must be packed in strong wooden cases holding not exceeding 100 lbs. of dynamite per case, not less than 5 lbs. per case, and must be plainly marked on three sides of the case with the name of the contents and the words "explosive" and "dangerous" so as to be seen by all those who handle it. When in bulk, in cases, explosives must be surrounded on all sides with at least 3 ins. of dry sawdust between the contents and the inside surface of the case. When in cartridges, each cartridge shall be surrounded on all sides with dry sawdust, and all interstices between such cartridges, and a space of at least 1 in. between the outer sides of such cartridges and the inside surface of the case shall be filled with dry sawdust.

The rate on dynamite between any two stations on the New York, New Haven & Hartford R. R. is 1 ct. per lb.; minimum charge $1 up to and including 4,000 lbs. Over 4,000 lbs. double first-class rate will apply, with a minimum charge of $40.

Dynamite when consigned to stations off of the New York, New Haven & Hartford R. R. line will be accepted only by special agreement, i. e., you to advise us destination, and the amount you intend to ship, as we have to procure authority from connecting line before forwarding this freight. If you intend making any shipments off of the N. Y., N. H. & H. R. R. line, it is well to advise a few days in advance that we may procure authority for forwarding this freight. Yours truly,

W. H. Bolander, Agent.

N. Y., N. H. & H. R. R. Co., Pier 50, E. R. Station,
New York, Jan. 31, 1903.

A Question and Answer Regarding Explosive Tests of Joveite.

Sir: I have read with interest the article on "Joveite" in your issue of Jan. 22. I have had something to do with explosives, and from my experience I cannot understand how it would be possible to explode a stick of Joveite on top of a closed box containing Joveite without exploding the contents of the box.

In the first place, if the Joveite is as powerful as dynamite, there would be nothing left of the box or the unexploded Joveite except a few scattered fragments. Second, if the thickness of a half-inch board, which is the material of which a box is made, would prevent the Joveite on the opposite side from being exploded, the probabilities would be that it would frequently happen that not all of the charge would be exploded, especially where it was a little scattered as would be the case in loading in rock seams or crevices.

Thanking you in advance for any information on this matter, I beg to remain, yours truly,

G. W. Hughes.

Earlston, Pa., Jan. 26, 1903.

(While, as stated in the article referred to by our correspondent, we did not witness the explosion of a stick of Joveite laid on a box of Joveite, we can say from the tests that were made that the detonation of such a stick would tear the box to fragments and scatter its contents, as surmised by our correspondent. Nevertheless the contents would not be detonated if packed with a layer of sawdust or the like around the outer sticks, as is the practice, for the detonating stick would be separated from sticks in the box not only by half an inch of wood, but by 1½ to 2 ins. of sawdust as well. As shown by the tests that were described in the article referred to, a stick of Joveite when exploded by a cap will not explode a neighboring stick only 2 ins. away. Of course the other stick will be torn to fragments and scattered to the four winds, but the fact that it has not exploded is easily shown by the different sound and different resulting hole when the two sticks are placed closer together so that the first stick does explode the other. Regarding the non-explosion of a scattered charge, it is unquestionably a fact that if Joveite is used in bulk, as in charging a rock seam, it must be poured in so as not to leave gaps of more than about an inch between adjacent parts of the charge. When used in cartridge or stick form with the new waterproof cloth cover, the sticks may be rammed with safety as in charging with black powder; and considering the fact that the drill hole is always somewhat larger than the stick when ramming is done the stick swells laterally and shrinks lengthwise (about 40%) under the ramming, completely filling the hole, and insuring contact of adjacent sticks.—Ed.)

Experience with the Metric System in Mexico.

Sir: I have read with some interest the discussion of the metric system in recent issues of Engineering News. I have used this system for over six years on railway location, construction and maintenance, and have appreciated its advantages since my first day's work with it. I notice that some of the arguments against this system seem to have some of the characteristics of a boomerang, as in your issue of Dec. 25, Mr. Robinson states that he had trouble with the metric system because his machinery was installed with U. S. measurements. Any dual system is worse than a single system, but how much worse is the present multiplex system now in use in the United States compared with any single system, whatever it may be.

The metric system is a single system and a decimal system; and it is the standard system in a much greater part of the civilized world.

The greatest field for the export of United States manufactures is certainly in the Latin-American countries, all of which use the metric system. France and Germany are catering to this trade, both with the metric system. We are laboring under a handicap which is recognized by a great many of the mills of the United States, as shown from the fact that they make plans, giving measurements in both feet and meters, thereby adding one more unit to the already overcrowded number of units now in use.

Mr. Robinson's stake marking (Eng. News, Jan. 15, p. 59) may be simplified by using 10-meter stations with two stations per chain. This retains the decimal system, and facilitates calculations. In figuring cubic contents, add end areas and move decimal point one point to left for cubic meters, instead of as with 100 ft. chain, adding end areas and dividing by 2. Each stake tells its own story and we do not have to stop and divide by 5,280, a process which is very often beyond the capacity of an otherwise good head chainman or stake marker. It is much easier to check cross-sections with your eye when using meters than when using feet.

I think we all recognize the superiority of the metric system, and it is being used to a very great extent in the United States, and coming into a more general use daily; but like every other improvement it meets with opposition from those who have fallen into a rut.

I dare say that 99 out of every 100 engineers in the Republic of Mexico prefer the metric system to the United States system, as the only trouble we have with the metric

system is when we have to drop it to use feet, which would not be the case were the meter the sole standard. The United States and Great Britain are the dogs in the mangers, and are preventing the entire world from fully enjoying the benefits of the metric system.

Yours truly, John W. Miles,
Assoc. M. Am. Soc. C.E.

Calle Benito Juarez 12,
Vera Cruz, Mexico, Jan. 21, 1903.

Experience of a Well-known Engineer with the Metric System in Foreign Countries.

Sir: During a recent visit to Mr. E. L. Corthell, in Washington, I enquired of him as to the use of the metric system in Mexico and foreign countries. I was especially interested in the question, since some statements have been made recently which give the impression that the use of the system in the so-called metric countries was not very general. At the time of my proposing the question Mr. Corthell had but a few minutes at his disposal, and stated that he would answer the question by mail, which he did in a letter dated Dec. 31. I have recently had a request from Mr. Corthell to forward you a copy of his reply to my question, and I herewith enclose the original letter. Respectfully,

S. W. Stratton.

Treasury Department, National Bureau of Standards,
Washington, D. C., Jan. 27, 1903.

(The letter enclosed is as follows.—Ed.)

S. W. Stratton, Esq., National Bureau of Standards,
Washington, D. C.

My dear sir: My interest, which I have had for many years, in the proposal to introduce the metric system in the United States, leads me to make some remarks based on my experience; and as the length and character of experience, which a man has had, gives value to his opinion, I will state that I have had more or less to do with the metric system in my professional work for the last 22 years, and I have been *obliged* to have to do with it, for the reason that everywhere outside the United States, where my professional work has led me, I have been compelled to use it, simply because I have found it prevailing throughout every department of engineering with which I have had to do in Mexico, the Continent of Europe and Argentine.

In 1890-92, I was Chairman of the Executive Committee of the International Engineering Congress, held at Chicago, at the time of the World's Fair, and when also the engineers of the United States established a headquarters for their professional brethren, of all classes of engineers—civil, mechanical, mining, metallurgical, naval and military. The work that I had charge of in organizing the Congress and establishing the headquarters required correspondence with engineers in 43 countries of the world, in arranging for papers to be presented to the various divisions of the Congress, and in connection with many other matters. During the last eleven years I have had a great deal to do with the examination of engineering works in Europe, and have had designing and constructive work in connection with harbor and other public works in Mexico and Argentine, and I am able to state from this long experience, that in all of these countries, there is no other measure used, by engineers at least, than the metric system. There may be, and there is, in the distant country districts, a relic of the former old Spanish measures, and the local measures of various kinds; but they are not legal, and are not generally used in the provinces even for general business purposes. The United States consuls, in giving the measures used in various countries, give these practically obsolete measures, simply because they find that they exist to a small extent. I can assure you, from practical experience, that for any one unacquainted with the metric system, it is almost impossible to do professional work in countries outside of the United States and Great Britain. The obstacles in the way of conversion of English and American units and measures to the prevailing system in Europe and South America and Mexico are seen in all cases where it is necessary to convert from one system to the other, particularly if a double conversion is necessary. For instance, in cement specifications, which as president of a board in Argentine I had to assist in drawing up, the conversion of pounds per square inch, into kilograms per square centimeter, or in pressures on foundations, to convert tons per square foot into kilograms per square centimeter.

In drawing up the specifications above referred to, it was necessary to obtain all information possible from the leading countries of the world which make and test Portland cement. The information that was obtained from nearly all countries of Europe, except Russia, was always in the metric measure; that from the United States was always with English measures, and the various conversions were very tedious to make. I mention the above simply to illustrate what is occurring every day in the experience of American engineers doing business in Europe, Mexico, Central America and South America. The present and future relation of the United States with the rest of the world require that we should adopt a standard which is almost universally employed in the markets where we wish to send out manufactured products and where our people are sending their capital to engage in large undertakings. Yours very truly,

E. L. Corthell.

Dec. 31, 1902.

CANDIDATES for the Iron and Steel Institute Scholarships, founded by Andrew Carnegie, should apply to Mr. B. H. Brough, Secy. Iron and Steel Institute, 28 Victoria St., London. Last year six scholarships of $500 each were given to men from different parts of the world. The Gold Medal was awarded to Dr. J. A. Mathews, New York. The object of these scholarships is not to aid ordinary undergraduate students but to aid those engaged in original research in iron and steel metallurgy. Candidates must be under 35 years old.

SALTING A MINE on a large scale is charged by the Venture Corporation of London, which has consequently brought a suit for $6 000,000 damages against the estate of W. S. Stratton. The Independence mine was reported by T. A. Rickard as having $7,000,000 of ore in sight, but a recent report by John Hays Hammond puts the value at $2,000,000 in sight.

PROPOSED CANADIAN STANDARD SPECIFICATIONS FOR PORTLAND CEMENT.

At the annual meeting of the Canadian Society of Civil Engineers, the proceedings of which are reported in another column of this issue, the special committee of the Society on hydraulic cements submitted a standard specification for Portland cement. A year ago the same committee reported a set of rules for standard Portland cement tests and the present specifications are supplementary to and co-operative with these rules. The specifications are as follows:

The whole of the cement is to be well-burned pure Portland cement, of the best quality, free from free-lime, slag dust, or other foreign material.

(1) FINENESS.—The cement shall be ground so fine that the residue on a sieve of 10,000 meshes to the sq. in. shall not exceed 10% of the whole by weight, and the whole of the cement shall pass a sieve of 2,500 meshes to the sq. in.

(2) SPECIFIC GRAVITY.—The specific gravity of the cement shall be at least 3.09, and shall not exceed 3.25 for fresh cement; the term "fresh" being understood to apply to such cements as are not more than two months old.

(3) TESTS.—The cement shall be subjected to the following tests:

(a) Blowing Test.—Mortar pats of neat cement, thoroughly worked, shall be troweled upon carefully cleaned 5-in. by 2½-in. ground glass plates. The pats shall be about ½-in. thick in the center and worked off to the sharp edges at the four sides. They shall be covered with a damp cloth and allowed to remain in the air until set, after which they shall be placed in vapor in a tank, in which the water is heated to a temperature of 130° F. After remaining in the vapor six hours, including the time of setting in air, they shall be immersed in the hot water and allowed to remain there for eighteen hours. After removal from the water the samples shall not be curled up, shall not have fine hair cracks, nor large expansion cracks, nor shall they be distorted. If separated from the glass, the samples shall break with a sharp, crisp ring.

(b) Tensile Test. (Neat Cement.)—Briquettes made of neat cement, mixed with about 20% of water, by weight, after remaining one day in air, in a moist atmosphere, shall be immersed in water, and shall be capable of sustaining a tensile stress of 250 lbs. per sq. in. after submersion for two days, 400 lbs. per sq. in. after submersion for six days, 500 lbs. per sq. in. after submersion for 27 days. The tensile test shall be considered as the average of the strength of five briquettes, and any cement showing a decrease in tensile strength on or before the twenty-eighth day shall be rejected. (Sand and Cement.)—The sand for standard tests shall be clean quartz, crushed so that the whole shall pass through a sieve of 400 meshes to the sq. in., but shall be retained on a sieve of 900 meshes per sq. in. The sand and cement shall be thoroughly mixed dry, and then about 10% of their weight of water shall be added, when the briquettes are to be formed in suitable molds. After remaining in a damp chamber for 24 hours the briquettes shall be immersed in water, and briquettes made in the proportion of one of cement to three of sand, by weight, shall bear a tensile stress of 125 lbs. per sq. in. after submersion for six days, and 200 lbs. per sq. in. after submersion for 28 days. Sand and cement briquettes shall not show a decrease in tensile strength at the end of 28 days, or subsequently.

(4) The manufacturer shall, if required, supply chemical analyses of the cement.

(5) PACKING.—The cement shall be packed either in stout air and water-tight casks, carefully lined with strong brown paper, or in strong air and water-tight bags.

(6) The manufacturer shall give a certificate with each shipment of cement, stating (1) the date of manufacture; (2) the tests and analyses which have been obtained for the cement in question at the manufacturer's laboratory; (3) that the cement does not contain any adulteration.

TESTS OF THE FRICTION OF BALL BEARINGS.*

By M. J. Golden,† M. Am. Soc. M. E.

The author made a series of tests, about three years ago, to determine a formula for use in designing ball bearings of the small sizes commonly used, when the plane of rotation of the balls is perpendicular to the axis of rotation. This is the common form in use in connection with bicycles, spindles and shop shafting.

The tests were made on balls that were respectively 0.25-in., 0.3-in., and 0.5-in. in diameter, and at speeds varying from 200 to 2,000 r. p. m.

It was found that when the speed was over 2,000 r. p. m., and especially above 5,000 r. p. m., that a shattering action was liable to occur in the bearing, and the friction would suddenly become excessive; usually necessitating a stoppage of the testing machine.

The machine used consisted of a heavy cast-iron base, made heavy enough and stiff enough to absorb a large portion of the vibration due to the rapidly moving parts. To the top of the frame was bolted a cast-iron planed table, and to this table, two carriages that were fitted with ball bearings, in which a shaft revolved. These bearings were used because of the ease of alinement with them; and by fastening a set collar on each side of one of them, end thrust is provided for. The following are the results of the observations made:

At high speeds (above 2,000 r. p. m. in the tests made) there was a tendency for the bearing to chatter and this tendency was more marked with the heavier loads, with the less accurately ground balls, and with the softer balls and races.

The balls and races were destroyed by first becoming pitted, and this pitting showed on both balls and races.

With the heavier loads the balls were destroyed by breaking into two parts, that seemed to have been sheared apart.

The balls and races became hot before loads were reached that tended to destroy them.

The tendency to heat and to chatter were reduced in a marked degree by the use of a lubricant, an oil giving the best results.

Calculations from the figures taken during the test gave the coefficient of friction to be 0.00475, or less than one-half of one per cent.; though in a few of the tests the figure was found to slightly exceed one-half of one per cent. The friction was slightly greater with the smaller balls and at the higher speeds.

The formula deduced was gotten from so small a range in the sizes of balls, and the degree of hardness in both balls and races was so nearly uniform in all those used, that it is not given to be used as a general formula, and only for what it may be worth after comparison with other formulas.

Let the diameters be taken in inches and the load in pounds, then

D = diameter of the path of the balls on the races.
d = diameter of the balls.
L = load.
F = friction.

$$F = L\left(.005 + \frac{.001}{d} + .005\ D\right).$$

The balls and races to be of steel and to be accurately ground and as hard as possible in temper.

NIAGARA FALLS POWER SUPPLY INTERRUPTED BY A FIRE.

By O. E. Dunlap.‡

All who have visited the great power plants at Niagara Falls, or know of their magnitude, will be interested in a serious accident which occurred at the plant of the Niagara Falls Power Co., on Thursday, January 29. Lightning struck and started a fire among the cables leading from Power House No. 1 to the transformer house; on these cables practically all of the current output of Power House No 1, 50,000 HP. is carried. The current is generated at a voltage of 2,200 and sent to the transformer station, where a portion of the current is raised to 11,000 volts for transmission to Buffalo and other distant points.

The power house and the transformer station are located on opposite sides of the headrace or inlet canal. A bridge crosses this canal, and the cables, 52 in number, are carried over on this bridge. At 10:45 p. m. of Jan 29, the bridge was struck by lightning, and the stroke shortcircuited some of the cables, and set their insulating covering on fire.

*Condensed from a paper read at the annual meeting of the American Association for the Advancement of Science.

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‡P. O. Box 35, Niagara Falls, N. Y.

Every possible effort was made to put the fire out, but the flames succeeded in getting a good start on the bridge and extended into the transformer station. All the generating machines were shut down. The firemen poured great volumes of water onto the bridge and into the transformer station, but despite their quick work, all of the cables on the bridge were destroyed. The bridge and transformer station were badly damaged by the fire, and the water thrown into the transformer station wet several of the big transformers, rendering them wholly useless until dried out.

The destruction of the cables cut off the Niagara power supply of Buffalo, the Tonawandas, Lockport, and the majority of the tenants of the Niagara Falls Power Co. In Buffalo the street lights went out, the trolleys stopped until the International Railway Company's storage battery was thrown in, and the cars on the Niagara Falls-Buffalo line and the Lockport-Buffalo line, as well as in Lockport ceased to run. For an hour or more after the fire the arc lights of Niagara Falls were out and the electric cars stopped. Every customer of the Niagara Falls Power Co. was without power for a short time at least, for until an examination was made after the fire, all current was shut off from both stations (i. e., Power House No. 1 and Power House No. 2, the latter having been only recently completed). The first service to be restored was that of the Niagara Falls electric railway and the arc lighting system, for this service comes through the rotary converters in Power House No. 1. All patrons of the company who received current that passed over the cables on the bridge were forced to wait until the temporary repairs were made.

The fire was hardly under control before Superintendent Barton was preparing to make repairs. Every man it was possible to put on the job was immediately set to work. Carpenters repaired the roofs of the bridge and the transformer station. The debris of the fire was cleared away. New cables kept on hand by the company, also some intended for use in Power House No. 2, and some the General Electric Co. had on the ground were brought to the scene, and the electricians of the company hustled them into place. By daylight Friday splendid progress had been made, and it was expected that Buffalo would be connected up by noon. However, a short circuit caused further trouble and it was 4.30 p. m. before current was flying over the transmission line to relieve Buffalo's distress. Before it was necessary to turn on the street lights Friday evening, Buffalo was receiving 10,000 HP., and soon afterward the full amount of Niagara power used in Buffalo was again passing over the cables.

From the time of the fire Thursday night until late Friday afternoon all of the industrial establishments in Buffalo that use Niagara power were idle. In some cases the men were kept in the plants hoping that the current would come from Niagara, while in other cases the men had a holiday. All of the factories in the Tonawandas that use the Niagara power were also forced to idleness, and the same may be said of the situation in Lockport. In Niagara Falls the majority of the tenants of the power company were without current, but a few that had been receiving power from Power House No. 2, the cables of which did not cross the burned bridge, were able to run on Friday. Some of the idle Niagara factories resumed operations Friday night. Cable connections were established as rapidly as possible. Fortunately for Buffalo, the Niagara Falls Power Co. had several large transformers that were not damaged by fire or by the water thrown into the transformer station, and so these machines were ready for service as soon as the cable connections could be installed.

Considering the extent of the trouble, it is generally agreed that the employees of the Niagara Falls Power Co. performed a wonderful feat in reestablishing connections as quickly as they did. The fact (if true—Ed.) that a January lightning bolt should cause such ruin has astonished everybody connected with the Niagara plants. If there had not been a large amount of cable immediately available at the Falls, or if the transformers had all been thoroughly wet, a long delay must have resulted, and the Niagara-Buffalo locality would have been greatly inconvenienced by the lack of Niagara power.

THE COLE-FLAD PHOTO-PITOMETER AND ITS USE IN STUDYING WATER CONSUMPTION AND WASTE.

Two notable attempts have recently been made to utilize the Pitot tube for measuring the flow of water in pipes under pressure. In each case the efforts have been directed largely towards the perfection of a recording apparatus. Mr. Walter Ferris, of Philadelphia, has patented a device for registering the results obtained by the Pitot tube.* He employs, in some manner not explained, a hydraulic motor, supplied through a second pair of Pitot tubes, to drive his recording apparatus.

In the other application of the Pitot tube, to which this article is devoted, the record is photographic. This device was patented by the late Henry Flad, of St. Louis, and Mr. Edw. S. Cole, of Chicago. It was used last summer to make a water-waste survey of Columbus, O., and is now being employed for a similar purpose in New York. Two descriptions of the apparatus have appeared,† each written by Mr. Cole. Fig. 1, reproduced from a photograph supplied to this journal by Mr. Cole, shows the general form and some of the details of the instrument. Fig. 2, from the Transactions of the American Society of Civil Engineers (see foot note), shows the tubes proper in detail. Fig. 3 is a reproduction of one of the records made at Columbus, supplied to us by Mr. Cole.

Mr. Cole states that the need for such an instrument was forced upon him in 1896, when there was occasion to measure the flow of water in the distribution system of the water-works of Terre Haute, Ind., for which Mr. John A. Cole, M. Am. Soc. C. E., was consulting engineer. As a result, the apparatus here described was developed, much experimental work having been devoted to it in 1896-7, and again in 1900-1. The following description is taken from the Journal of the Western Society of Civil Engineers, already named:

This instrument is primarily a rate meter, depending as it does upon the velocity of the water within the main. It does not directly indicate the total discharge in cubic feet in a given time, as with ordinary meters. This elimination of the time element is necessary in a waste meter, for by the change in rate we are able to study the effect of closing valves and service cocks in such an investigation as I have just described. The illustration gives a general idea of the complete instrument with its photo recorder.

Two brass tubes bent at their lower ends, with carefully formed orifices of ⅛-in. internal diameter, are held in a suitable cap which screws upon a standard 1-in. corporation cock, through which the tubes may be readily introduced into any main and as easily withdrawn.

Heavy cloth-insertion rubber tubing connects the orifice tubes with a long glass manometer or U-tube and blowoff cocks are provided to remove air from the instrument. The U-tube is half filled with a mixture of carbon-tetrachloride and gasoline having a specific gravity of 1.25, and when in use the water from the pipe fills all the space in the U-tube and connections. The orifices are set to receive the maximum velocity within the main, which is usually near the center, and is readily indicated by the deflection in the manometer. This deflection, by virtue of the differential action of the water and the slightly heavier and insoluble liquid, is just four times that due to the actual difference of water head on the orifices produced by the flowing stream. The current impinges directly on one orifice, but the other is turned down stream and gives something less than the static head within the main, thus magnifying the difference of pressure produced. This difference is then multiplied in the U-tube, the result being that a low velocity within the pipe produces a readable deflection. Without this effect the Pitot tube would hardly indicate a velocity less than 1 ft. per sec., while the pitometer may be depended on, if carefully used, to measure velocities as low as 4 ins. per sec. At the ordinary velocities the U-tube deflections may run up to 24 ins., and need not be read with any great nicety. The photo-recorder consists of a box in which a drum carrying Velox paper revolves before a fine vertical slit just in front of which is locked one leg of the U-tube, in such a position that the rays of light from an oil lamp will be partly intercepted on their way through the colored liquid in the lower half of the manometer As the liquid rises and falls with the

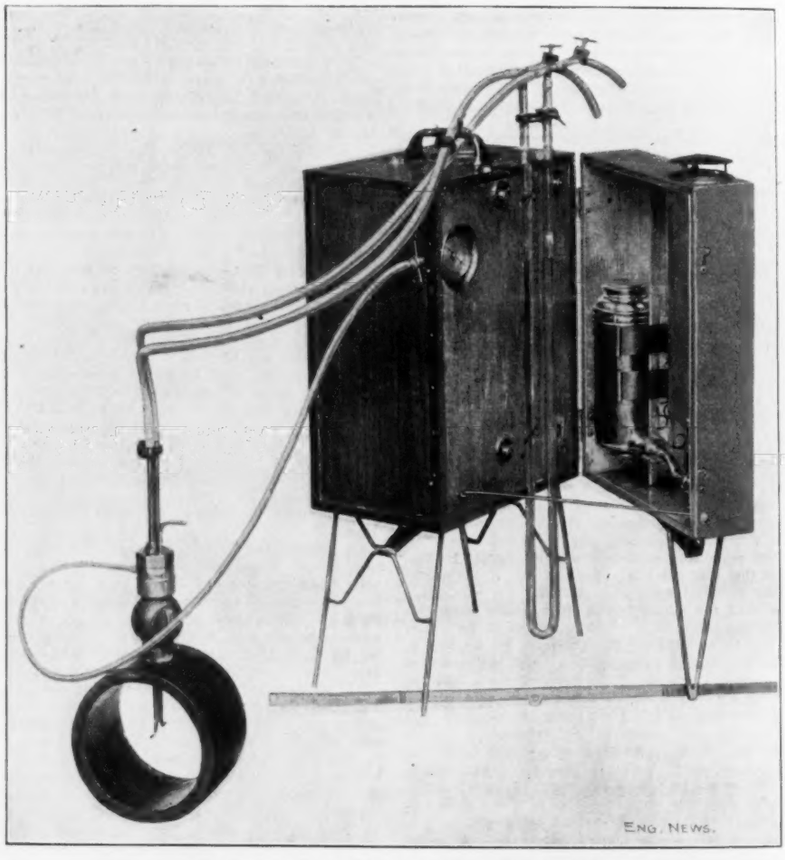

FIG. 1. VIEW OF THE PHOTO-PITOMETER.

*See Trautwine's "Civil Engineer's Pocket-Book." 18th edition, p. 536.

†See "Trans. Am. Soc. C. E.," Vol. XLVII., pp. 275-83 (1902), and "Jour. Western Soc. C. E." Vol. VII., pp. 574-88 (1902).

velocity in the pipe it will record a line or band of shade on the Velox paper whose ordinates vary according to the well-known formula:

$$V = c\sqrt{2gh},$$

in which "h" is one-quarter of the U-tube deflection in feet or half of the recorded ordinate on the paper. A 12-hour photographic record is 18 ins. long and 10 ins. high. Autographic horizontal lines are formed by notches in the drum slit, spaced so as to correct for the angularity of the light and enable the deflection to be readily taken from the diagram at any point. (A detent attachment on the drum temporarily arrests its motion every two hours, thus producing vertical base lines for time measurements on the record.)*

The accuracy of the pitometer has been established by many weir tests and by calibration in open channels (a specially designed open trough)‡ where the absolute velocities indicated by the instrument were compared with float

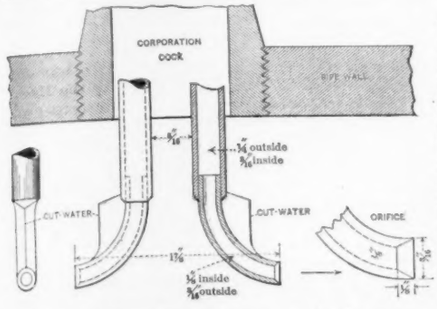

Fig. 2. Details of Pitot Tubes as Applied to the Pitometer

measurements. (The pitometer orifices were introduced through the bottom of the trough so that the instrument was completely below the water level and operated under the conditions of actual service. The floats were carefully timed with a stop watch over a long course, sometimes 40 ft. in length, and were loaded so as to run as nearly at the level of the orifice as possible. These calibration tests included velocities as high as 12 ft. per sec.)‡

The calibration constant "c" of the orifices has thus been experimentally determined to be .80 in our formulas.

We have then

$$V = .8\sqrt{\frac{2gd}{4}} = 3.212\sqrt{d},$$

in which d is the U-tube deflection in feet. The actual velocity of the water is indicated in this way wherever the orifices may be placed within a pipe, and by completely traversing a given pipe section on one or two diameters we may easily compute the ratio of mean to maximum velocity at some one rate of flow. This ratio once determined for a given pipe holds good at all velocities. We may then set our orifices permanently to give the maximum or center velocity within the pipe, reading off the mean velocity and the discharge from a table constructed for the particular size of pipe and velocity rates. This method leaves nothing uncertain, and after computing the traverse of many pipes varying in diameter from 4 to 72 ins., and with different conditions as to interior roughness, I am satisfied that the method is a reliable one. The mean velocity computed from a traverse of a pipe with the pitometer has been checked by actual weir and pump measurement of the flow in pipes with close agreement. I have reason to believe that the flow may be determined by the pitometer method within 2 or 3% of the truth in fairly clean pipes when the velocity exceeds 1 or 2 ft. per sec. Velocities as low as 4 ins. per sec. may be measured, but with less precision.

It is obvious that the ready portability of the pitometer, combined with its ease of attachment to the mains, renders it particularly available for waste-water surveys, or any other short-time studies of the flow of water in pipes.

ANNUAL MEETING OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

The Canadian Society of Civil Engineers held its seventeenth annual meeting at its rooms on Dorchester St., Montreal, Jan. 27, 28 and 29. The Society has now passed the thousand mark in its membership. Both as to the number in attendance and as to the character of the papers read, the meeting was decidedly successful.

LIQUID AIR EXHIBITION.—After the transaction of general business on Tuesday, there was an exhibition of the liquid air plant in the Physics Building, McGill University, where Prof. Cox gave a short lecture, followed by some interesting experiments with liquid air. To engineers perhaps the two most interesting experiments were those showing the great reduction in electrical resistance of copper, upon immersion in liquid air, and the magnetic property of liquid oxygen. The intense cold of the liquid air reduced the resistance of a copper coil from 17 ohms down to 4 ohms; and, commenting upon this, Prof. Cox observed that in the future it might not be impracticable to freeze underground conduits, and keep them frozen for the purpose of reducing the necessary weight of the wire conductors.

After this exhibition, a visit was made to the engineering laboratory, where tests were made to determine the strength of a block of ice, of wooden beams, etc.

PROGRESS OF ENGINEERING WORK IN CANADA.—At the evening session on Tuesday, Dr. Martin Murphy, President of the Society, delivered his retiring address. Among the many interesting facts brought out is the following, that 320 highway bridges of metal superstructure, resting on abutments and piers of concrete, have been built in Nova Scotia within the last 18 years, some of them within the influence of the turbulent tides of the Bay of Fundy, most of them exposed to heavy drift ice, and all of them to the extremes of climatic exposure. Yet but one failure can be recorded, and that is, no doubt, owing to careless workmanship. The introduction of concrete as a substitute for masonry, above the surface, has been attended with such results that its employment is being extended and adopted for the renewal of masonry piers of railway bridges—piers that have been so abraded and displaced by clumps of moving ice that renewal in the interest of safety becomes imperative.

Further on in his address, Dr. Murphy, speaking of the timber of Canada, emphasized the growing importance of using some timber preservative, to illustrate which he said that the life of the ordinary spruce tie is about 8 years, but that its life might be extended to 24 years by creosoting.

It is a fallacy to consider that the spruce sleepers in this country cannot be effectively treated by creosote. Thirty-five years ago timber shipped from Quebec was creosoted in England, transhipped to Sydney, Cape Breton, and was employed there in a coal shipping pier. The "teredo" is so destructive in Syndey harbor that the hull of a boat unsheathed in the summer season cannot rest in the stream for three months without being completely riddled, yet this wharf or pier for over 30 years' exposure has withstood their attacks.

There is still a greater need of a large plant for creosoting heavy timber along our coasts, where the "Teredo Navalis" and the "Limnoria Lignorum" are active. We are aware that the engineers of the Public Works Department of Canada have made repeated representations to that department, urging the necessity of installing creosoting plant for piling and for wharf building along our shore.

Dr. Murphy enumerated 13 Canadian water-power plants developing a total of 390,000 HP., mostly used for electric railway purposes. Attention was directed to some enormous sources of power still undeveloped as follows:

	HP.
Ottawa River	890,000
Shawinigan Falls	200,000
Niagara Falls (Ontario Power Co.'s right to develop)	400,000

SOME PROBLEMS IN CONNECTION WITH THE ERECTION OF THE MIRAMACHI BRIDGE.—This paper, by Mr. H. D. Bush, we hope to find space for in a following issue. We may remark here that the problem of bridge erection was solved by floating the new spans to place on scows. The paper was well illustrated with lantern slides.

TIDE LEVELS AND DATUM PLANES IN EASTERN CANADA.—This was the title of a paper read by Mr. W. Bell Dawson, D. Sc., F. R. S. C., Engineer-in-Charge of the Tidal Survey of Canada. For eight years Mr. Dawson has had charge of the Tidal Survey, and in connection with this work has accumulated a vast amount of data relative to tide levels and bench marks. In this paper are given the descriptions of many bench marks and their elevations, also ties to railway and other bench marks, and elevations of tide levels. The writer emphasized the importance of establishing permanent bench marks on railway surveys and the like. Otherwise much valuable data are often lost entirely, a case in point being the old survey for the European and North American R. R., from St. John to Shediac. It was impossible to find any original bench marks. In the discussion that followed the reading of this paper, it was stated that the mean sea level of the lower St. Lawrence River and of New York harbor differ by about 4 ft. However, there appears to be considerable doubt as to the tying of the Canadian to the American surveys, and this doubt is not lessened by the fact that while formerly it had been stated that mean sea level at New York was several feet higher than on the St. Lawrence, the reverse now appears to be the case, since Mr. Dawson has carefully tied the Canadian bench marks one to another.

THE HYDRAULIC DREDGE "KING EDWARD VII."—In a short paper, Mr. A. W. Robinson, the designer of this dredge for the Canadian Government, described its salient features, accompanying his description with lantern slides. By his courtesy we shall be enabled to reproduce some of the photographs in a later issue. In the discussion that followed the reading of the paper, Mr. Robinson said that this dredge cost $91,515; that the centrifugal pump has an efficiency of about 60%; that the crew is 11 men; and that the average output is 500 cu. yds. of material per hour through a pipe 1,500 ft. long; and that the pipe suffers no appreciable wear from the grit, and the pipe being very thin, rusts out before it wears out. He also stated that the solid material constituted 15 to 25% of the whole mass delivered through a long pipe, although 50% may be delivered through a very short pipe where precipitation cannot occur; and in this connection he added that he is now experimenting with a novel apparatus for pumping what virtually amounts to a viscous mud containing 80 to 90% solid matter.

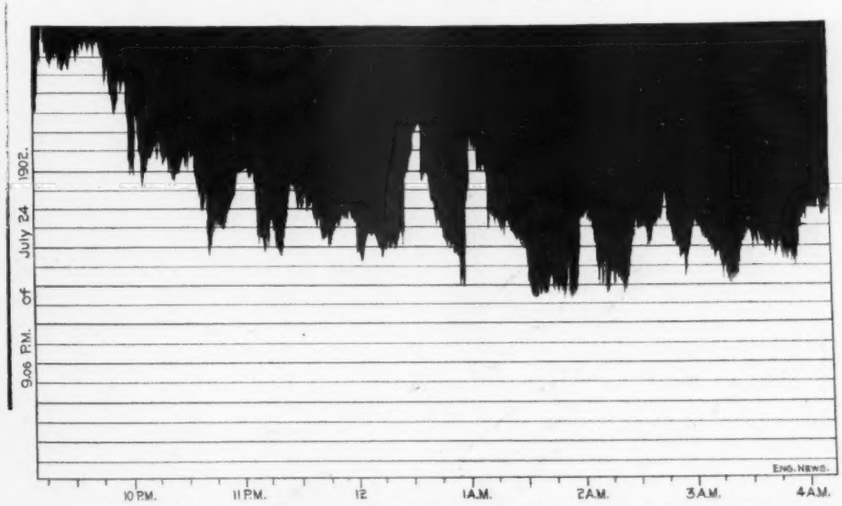

FIG. 3. RECORD SHEET OF PHOTO-PITOMETER TAKEN AT COLUMBUS, IND.

THE FLOW OF STREAMS.—In this valuable paper Mr. R. S. Lea has collected practically all the reliable data in engineering literature on the flow of rivers in the United States, there being

*The matter in parentheses has been added by Mr. Cole on the proofs of this article.

almost nothing published about Canadian streams. The paper is far too voluminous, however, for us to attempt to reproduce.

THE ECONOMY OF SMALL GAS ENGINES.—This paper, by Mr. H. M. Jaquays, gives the results of actual tests of gas engine efficiency using Montreal illuminating gas. With reference to brake horse-power, the mechanical efficiency of one engine was 70%, and of another engine 80%. The average calorific value of the gas now used was 620 B. T. U. (actual, and 664 theoretical) per cu. ft. of gas. Engine No. 1 was Otto cycle, 8½ × 12-in. cylinder; engine No. 2 was Atkinson cycle, 7½ × 8½-in. cylinder; and both had hot tube igniters and governors of the hit-and-miss type.

THE INDUSTRIES OF THE CONSOLIDATED LAKE SUPERIOR CO.—In this paper Mr. E. G. M. Cape gave a very full description of the so-called Clergue plants at and near Sault Ste. Marie. A short description was given of the process of roasting nickeliferous pyrrhotite (3% Ni). The roasted ore is briquetted and the SO_2 is used in making calcium sulphite for the chemical pulp manufacture. To make one ton of this pulp requires 2.2 cords of wood, 500 lbs. of SO_2 and 450 lbs. of limestone. Delivered at the mill these materials cost as follows: Wood, $5 per cord; gas ($SO_2$), $15 per ton; limestone, $1.75 per ton; to which add $10 per ton of pulp for labor and power, making a total cost of about $25 per ton of pulp.

This paper was brought to a close with a description of the alkali works, where salt is electrolytically decomposed, producing Na and Cl, the former forming caustic soda, and the latter bleaching powder. The most interesting feature of the process is the use of a cell having a mercury cathode which forms an amalgam with the sodium as it is freed; then a circulation of the mercury brings the sodium in contact with water producing the sodium hydrate. The chlorine freed at the carbon anodes passes into a chamber containing slaked lime, with which it unites, forming bleaching powder. A current of 1,000 amperes at 5 volts passes through each of the 120 cells to decompose the brine. With an A. H. efficiency of 90% these 120 cells have a daily capacity of 9 tons 941 lbs. of bleaching powder and 4 tons 565 lbs. of caustic soda.

REPORTS OF COMMITTEES.—As an outcome of Mr. Lea's paper it was resolved,

that in view of the importance of full information in connection with the flow of streams and the insufficiency of existing data, that Messrs. R. S. Lea, C. H. Rust, J. S. Kerry, G. B. Smith, R. B. Rogers and C. H. McLeod be appointed to consider the practicability of inaugurating a more complete series of measurements in this connection than has hitherto been undertaken.

This special committee will report to the council which will co-operate with them, either directly or by a memorial, to the Dominion Government as may seem most desirable.

The committee appointed to consider the advisability of dropping the word "Civil" from the title of the Society reported adversely; and the sentiment of the members appeared overwhelmingly against any change of name. Prof. Henry J. Bovey made a strong plea for the continuance of the committee. He maintained that it would be very unfortunate if a multitude of engineering societies were to spring up, when one society could and should embrace all the engineering professions. He pointed out that, in Canada and the United States, mechanical electrical and mining engineers do not consider themselves to be civil engineers, as is the case in England; but that the four great engineering professions have so much in common that the interests of each would best be subserved if all were united in one strong society. A committee was finally appointed to consider the best way of bringing mining, electric and mechanical engineers into the society, and to report upon the advisability of forming separate branches, if need be, under the one head.

REPORT OF THE COMMITTEE ON CEMENT TESTS.—This committee presented a progress report a year ago, and this year completed its work, by presenting a standard specification for Portland cement. The specification is printed elsewhere in this issue.

NEWEY ELECTED OFFICERS.—The following is a list of the officers elected for the coming year:

President—K. W. Blackwell, Montreal.

Vice-Presidents—G. H. Duggan, Sydney, C. B.; E. Marceau, Montreal; G. A. Mountain, Ottawa.

Treasurer—H. Irwin, Montreal.

Secretary—Prof. C. H. McLeod, Montreal.

Librarian—E. G. M. Cape, Montreal.

Councillors—C. H. Keefer, Ottawa; J. Kennedy, D. Macpherson, S. Howard, W. McL. Walbank, R. A. Ross, Montreal; C. E. W. Dodwell, Halifax; W. B. Mackenzie, Moncton; C. B. Smith, Niagara Falls; R. B. Rogers, Peterboro; E. Mohun, Victoria; J. Galbraith, Toronto; W. R. Butler, Kingston; St. T. J. Boswell, R. A. Vallee, Quebec.

Nominating Committee—Maritime Provinces, C. W. Dodwell; Quebec, R. A. Vallee, W. McL. Walbank; Ontario, W. P. Anderson, G. A. Mountain, C. H. Rush; Manitoba, H. J. Cambie; Outside of Canada, R. A. Ross.

President-elect Blackwell is an Englishman by birth. He was educated at Bishop's College School, Lennoxville, and in England. He was in the railroad service from 1867-83, first in the Grand Trunk, in which he held the position of mechanical superintendent of the Chicago branch, and from 1881-83 with the Canadian Pacific as general superintendent of rolling stock. Since 1883 he has been in the iron and steel manufacturing business.

SOCIAL FEATURES.—On Tuesday afternoon, following the liquid air exhibition, there was an informal reception and afternoon tea in the Macdonald Engineering Building, by the courtesy of the Governors of McGill University.

Both on Wednesday and Thursday there was an informal luncheon at the rooms of the Society, and on Wednesday evening the annual dinner was given at the Windsor Hotel. Dr. Martin Murphy presided, and the guests, to the number of one hundred, were seated around a horseshoe table. After the health of the King had been duly honored, Mr. W. T. Jennings proposed the toast "The Guests," to which responses were made by Mr. F. H. McGuigan, Manager of the Grand Trunk Railway; Professor Cox, and Mr. J. T. Knight. "The Sister Societies" was proposed by Col. Anderson, and was replied to by Mr. R. S. Buck, M. Am. Soc. C. E.; Mr. W. E. Doran, President of the Association of Architects of Quebec; Mr. C. H. Rust, President of the American Society of Municipal Improvement; and Mr. Gastonguay, President of the Quebec Association of Land Surveyors.

SUMMER MEETING.—The Council is to submit to the members, by letter ballot, two or more routes for the summer excursion, also two or more months in which the excursion shall take place. Some members present suggested chartering a steamer from Buffalo for a trip up the Great Lakes in September, but it remains for the Council to outline alternative routes.

FIG. 1. REDLANDS, CAL., WITH SIERRA NEVADA MOUNTAINS IN THE DISTANCE.

(The depression in the hills near the center of the picture shows the mouth of the Santa Ana Cañon. Mill Creek Cañon is to the right of Mount San Bernardino at the right hand end of the picture. The new power plant is located in this cañon about twelve miles from the city.)

THE NEW MILL CREEK POWER PLANT OF THE EDISON ELECTRIC CO., NEAR REDLANDS, CAL.

By E. Duryee.*

Among the first of the now numerous electric power companies in Southern California were the Redlands Electric Light & Power Co., and the Southern California Power Co. The plant of the first company named was the earliest electric power development of any importance in Southern California. It supplies the city of Redlands with light and power, and also distributes current to Riverside, Colton and Highlands, principally for lighting and pumping purposes. The Southern California Power Co.'s plant in Santa Ana Cañon, will be remembered as the pioneer in long distance transmission in this country. The current was successfully transmitted 82 miles to Los Angeles at 33,000 volts pressure. These two companies have recently been absorbed by the Edison Electric Co., of Los Angeles, Cal., and that company has issued $10,000,000 for improvements. It now has under construction a power plant of 25,000 HP. on Kern River, which will send current 120 miles to Los Angeles, and is adding a third plant to the two now in operation in Mill Creek Cañon. This plant is now nearly completed. The new power plant in the Mill Creek Cañon is known as power plant number three. The work of construction has been in progress for over a year. The pipe line under the direction of Mr. F. C. Finkle, Chief Hydraulic Engineer; and the power houses under Mr. O. H. Ensign, superintendent of the Edison Electric Co., of Los Angeles. The power house is located twelve miles north of Redlands, Fig. 1, in Mill Creek Cañon, but the water is taken from the stream five miles further up the cañon at an elevation of about 6,000 ft. above sea level. This intake is a tunnel 350 ft. long through a spur of the mountain, and extending under the bed of the stream, 15 ft. below the surface. This tunnel will collect the flow and underflow of the creek, the surface flow coming in through a shaft. It will deliver the water to a flume, a short one and the only flume along the line. It is 200 ft. long by 4 ft. wide and 3 ft deep, built of surfaced redwood lumber. Fig. 2 is a view showing a novel device used in this flume to remove leaves and twigs from the water before it enters the pipe line. As will be seen it consists of an endless wire screen, the lower end of which is immersed in the flume, which is wound slowly over two drums thus catching and carrying the floating material from the water and dropping it in a heap beneath the upper end. Motion is given to the screen drum at the upper end by a sprocket chain operated by an undershot wheel turned by the current in the flume. This is a simple and efficacious device which will be of interest to engineers.

The flume will deliver the water to the sand box, Fig. 3, which is 100 ft. long by 50 ft. wide. It has eight chambers, 12.5 ft. wide by 50 ft. long; the slope in each of these towards the gate will be 4 ft. in 50 ft., and all the dividing walls between the chambers will be 3 ft. below the water surface in the sand box except the middle wall, which will be higher than the water surface, and allow the water to pass through a gate, instead of over the wall.

From the sand box the water enters the gravity cement pipe line, which is 30 ins. inside diameter and 25,000 ft. long. The sections of pipe were made in camps located as near the place where they were required as possible. Portland cement was delivered from the cement works 20 miles distant. It had to be hauled from six to twelve miles up the cañon. The gravel used with it in making the pipe was found nearby in the bed of the creek. The gravel was screened through a 2-in. screen to take out all larger pebbles. The proportions used were one of cement to three of gravel. This material was mixed dry by hand and then ¾ gallon of water to a cubic foot of the mass was added, and after further mixing wet, it was tamped into the iron forms in the usual way. The shell of the pipe was 2¾ ins. thick, and the sections were 2 ft. long. The cost of the pipe was $1 a foot. It cost about half a dollar more to dig the trench, and another half dollar to hoist the pipe, lay them and cover with dirt. The pipes were supposed to be kept wet by frequent sprinkling for a fortnight after being made, and then lay on the ground for several months until they were required for use, Fig. 4.

The grade of the pipe line ran along the side of the mountains, from half to three-quarters of a mile above the camps where the pipes were made. It became necessary to rig up electric hoists at each camp to operate a trolley for hoisting the pipe up to the trench. For this purpose lines of wire were run up the cañon from the company's No. 2 power house. The pipes were then brought on stone sleds to the hoist, Fig. 5. two of them were strung together and hooked to the trolley, and elevated from 2,400 to 4,500 ft to the line of the trench. They were then rolled along to their places in the line, sometimes it was necessary to roll them half a mile along the trench. The pipe weighed 510 lbs. each, and the trolley 700 lbs. A 20-HP. motor was used to operate the hoist.

At points where the line crossed cañons inverted siphons are required. There are five of these as follows:

No. of siphon.	Length.	Diameter of pipe.	No. of siphon.	Length.	Diameter of pipe.
1	350 ft.	30 ins.	4	150 ft.	30 ins.
2	315½	22 "	5	2,150 "	22 "
3	120 ft.	30 "			

The profile of the line insures a hydraulic head on each siphon that makes the carrying capacity of each 20 second-feet of water, although they vary in diameter. All the siphon pipes, as well as the cement gravity line of pipe are laid in trenches 3 ft. deep, the concrete pipes are jointed with heavy cement collars outside, and smoothly plastered inside at the joints. The trench is back-filled to cover the pipe 3 ft. deep. The grade of the gravity line is 0.2 ft. per 100 ft., which gives a carrying capacity of 20 cu. ft. per second, or 1,000 miners' inches under 4-in. pressure. There are nineteen tunnels along the line, varying from 100 ft. to 1,000 ft. in length, and aggregating 7,490.6 ft. in length.

At the end of the gravity pipe line is located the forebay, sufficiently large to hold 10 second-feet of water continuous flow for six hours. This storage of surplus water at times when the load is light on the power plant becomes available at the time of the peak load, extending over six hours daily. The forebay is made by throwing an earthen dam 20 ft. long on the bottom, 166 ft. on the top, and 30 ft. high, across a ravine at the head of the force main. The dam is paved on the up-stream slope with Portland cement mortar. The great value of this storage in connection with this new No. 3 power plant will be appreciated when it is remembered that 10 second-feet for six hours through power plant No. 3 gives 1,500 actual electrical horse-power during that time, and 400 more such horse-power through the company's No. 1 plant, through which the water will also pass after leaving No. 3 plant.

The force main line receives the water from the forebay. This line is 8,400 ft. long, and has a fall of 1,906 ft. from the forebay to the power house floor, Fig. 6. The main part of this line consists of 2,485 ft. of 26-in. pipe, 2,150 ft. of 24-in. riveted pipe, and 3,450 ft. of 24-in. lap welded pipe, with 82 ft. of 18-in. and 233 ft. of 14-in. pipe for branch lines to the four different units. The first 2,150 ft. of 24-in. and all 26-in. pipe is continuous, riveted pipes varying in thickness from No. 14 to 000 B. W. G., and all other 24-in. pipe is lap-welded of ⅝ and 7-16 to ⅞-in. thickness. The 18 and 14-in. branch pipes are also lap-welded and ⅝ and ½-in. thick, respectively. The material used for all the pipe is open-hearth annealed steel of 40,000 to 60,000 lbs. tensile strength per square inch. All joints except those used in laying the 18 and 14-in. branches and 620 ft. of lap-welded pipe are riveted, the latter are made with solid welded steel flanges. The branching of the main line pipe is done by means of cast steel Ys and curves having radii from 9 to 12 ft. All flanges on these specials are also of cast steel. The line is equipped with air valves, blow-offs and pressure alleviators.

The power house is of monolithic Portland cement, concrete construction, with iron roof trusses and galvanized corrugated iron roofing. The original south end of the building which has housed the No. 2 power plant for several years was of the same construction, and when it was erected it was built with a view to enlarging in the way that has now been done, Fig. 7. This old part contains two direct-coupled Pelton water wheels with three-phase alternating current gen-

FIG. 2. TRAVELING SCREEN FOR REMOVING TWIGS FROM WATER.

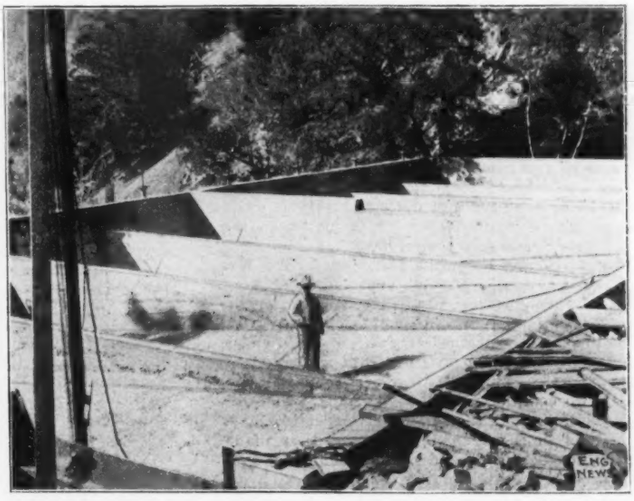

FIG. 3. SAND-SETTLING BASINS AT END OF FLUME.

*Colton, Cal.

erators of 11,000 voltage, with a capacity of 300 HP. each. The gravity portion of the pipe line to this part of the plant was made of cement pipe 22 ins. in diameter, and carried 500 ins. of water. The fall was not nearly so great as in that of the new No. 3 line. The dimensions of the power house are: Length inside, 116 ft. 8 ins.; width, 33 ft. 8 ins.; height of walls, 17 ft. 10 ins. The east wall is 2 ft. thick, and the west wall is 21 ins. thick to within 4 ft. 6 ins. of the top of the walls, where it is reduced to a 12-in. thickness. This is to leave a shoulder for the track for the electric traveling crane used in moving machinery. The north end wall is 18 ins. thick. There are four wheel pits. The piers are built of rubble concrete, each containing 70 cu. yds. The mortar was made in the proportion of one of cement to seven gravel, and as it was put into

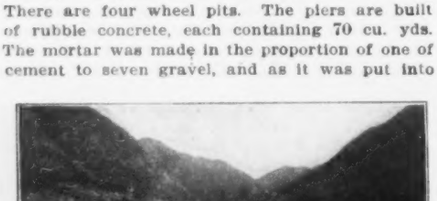

Fig. 4. Sections of Cement Pipe for Gravity Pipe Line Stored for Seasoning.

the forms in a very wet mass boulders were embedded in it to bring the proportions up to one of cement to twelve of aggregates. It took 14 men 1 day and 6 hours to build a pit. For this new No. 3 plant there are four units of 1,200 HP. each, the voltage is to be 33,000, the same as on the company's Santa Ana Cañon line.

In constructing the walls and piers a very wet concrete was used. The laborers employed were most of them inexperienced in concrete making. The forms were set up in heights of about 5 ft. at a time, and the concrete was put in place as fast as possible. No attempt was made to get smooth walls, but afterwards the walls were given two coats of plaster in finishing. The tail races were built in the same way, except in some places, as in the arch, the concrete were made richer in cement, one of cement to four of gravel was used in the arch of the tail race.

The amount of power available at the power

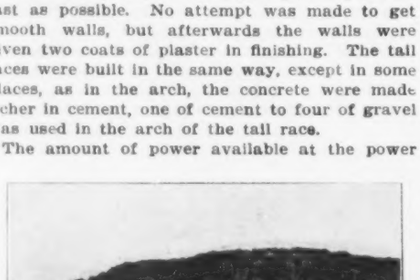

Fig. 6. View Showing Trench for Pressure Pipe Line, with 1,906-ft. Fall to Power House.

plants varies with the flow of water in the creek. Recently the water has been low and the power output has been below the capacity of the plants. Power house No. 1 has developed about 1,100 HP.; No. 2 about 600 HP., and it is expected that the new plant, No. 3, will give 1,900 HP. at the lowest flow of the stream during dry seasons. This new No. 3 plant will be completed about Feb. 1, and the total cost of the improvements will be $235,000.

SMOKE PREVENTION AT ST. LOUIS, MO.

Notable progress in smoke prevention has been made at St. Louis since 1901, when State and municipal legislation was secured declaring the emission of "dense smoke" within the city to be a nuisance, and providing for a number of smoke inspectors. Under a municipal ordinance, approved on Aug. 21, 1901, Mr. C. H. Jones was appointed Chief Smoke Inspector. Since Oct. 1, 1901, all the boiler plants in the city, some 1,200 in number, have been classified, and up to Jan. 1, 1903, 844 of these had installed devices for the prevention of smoke.

The legislative act of 1901 is as follows:

Section 1. The emission or discharge into the open air of dense smoke within the corporate limits of cities of this state which now have or may have hereafter a population of 100,000 inhabitants, is hereby declared to be a public nuisance. The owners, occupants, lessees, managers, or agents of any building, establishment or premises from which dense smoke is so emitted or discharged, shall be deemed guilty of a misdemeanor, and upon conviction thereof in any court of competent jurisdiction, shall pay a fine of not less than $25 nor more than $100, and each and every day whereon such smoke shall be emitted or discharged shall constitute a separate offense. Provided, however that in any suit or proceeding under this act it shall be a good defense if the person charged with the violation thereof shall show to the satisfaction of the jury or court trying the facts, that there is no known practicable appliance, device, means or method by application of which to his building, establishment or premises the emission or discharge of dense smoke complained of in that proceeding could have been prevented.

Sec. 2. All cities to which the provisions of this act are applicable are hereby empowered to enact all necessary or desirable ordinances, not inconsistent with the provisions herein nor any general law of this state, in order to carry out the provisions of this act.

The St. Louis municipal ordinance of 1901, as amended in August, 1902, first recites the substance of Sec. 1 of the State law. It then creates a "Smoke Abatement Department of the City of St. Louis," and authorizes the mayor to appoint, subject to the approval of a majority of the members of the City Council, a chief smoke inspector, and not to exceed five deputy inspectors, who "shall hold their respective positions during the pleasure of the mayor." The chief inspector receives $1,500, and each of the deputies $1,000 a year. The chief inspector is placed "under the supervision of the mayor," controls the deputies, and reports to the mayor. The chief and his deputies are authorized to enter premises for purposes of inspection at all reasonable hours, in order to ascertain whether or not there is any known practicable device, appliance, means or method by the application of which to said building, establishment or premises the emission or discharge of dense smoke therefrom into the open air could have been or can be prevented.

The ordinance makes it the duty of police patrolmen and officers to assist the smoke inspectors in the performance of their duties, and to report to the chief of police all violations of the ordinance which come to their notice, he in turn to report them to the chief smoke inspector. Finally, any person interfering with the smoke inspectors when discharging their duties is to be deemed guilty of a misdemeanor and to become liable, on conviction, to a fine of not less than $25 nor more than $100.

On the same date as the amending ordinance just outlined (Aug. 27, 1902), another ordinance was passed which virtually extends the provisions of the ordinance governing buildings, so as to cover water craft and locomotive engines. This ordinance was printed in Engineering News of Sept. 18, 1902.

Immediately upon the organization of the smoke department, the work of obtaining and classifying records of all the boiler plants in the city was begun. The records were entered upon cards 6 ins. wide and 4 ins. high, printed on one side in the form of a record blank, and ruled on the other side for convenience in making notes. The printed matter was as follows:

(Each card 6 x 4 ins.)

1. Full name. (Firm, individual or corporation).....
2. Location of establishment.....
3. Name of building (if any).....
4. Kind of boiler or boilers.....
5. Number of boilers.....
6. Capacity of boilers.....
7. Working hours:
   (a) Establishment opens .....
   (b) Establishment closes .....
8. Dimensions of establishment.....
9. Height of smokestacks.....
10. Diameter of stacks .....
11. Height of stacks as compared with surrounding buildings .....
12. Nature and size of boiler and furnace rooms.....
13. Class of fuel.....
14. Kind of device (if any).....
15. Special facts .....

For violations of the ordinance, cards of the same size and general style, except that their color is blue, are used. The printed matter which they contain is as follows:

(Each card 6 x 4 ins.)

1. Full name of the corporation, firm or individual.....
2. Whether plant is controlled as owner, lessee, occupant, manager or agent.....
3. Name (if any) of building.....
4. Location of establishment.....
5. Date, hour and duration of violation.....
6. Volume and character of smoke.....
7. Date of prior violation (if any).....
8. Efforts (if any) to abate the smoke.....
9. Character of device (if any).....
10. Special facts (if any) relating to plant:
    (a) Character of fuel .....
    (b) Draft .....
    (c) Boilers .....
    (d) Furnace room .....
    (e) Character of engineer or fireman in charge as respects efficiency .....

Fig. 5. Electric Hoist and Cableway for Distributing Pipe Along the Trench.

The 844 devices, or smoke prevention methods, installed between Oct. 1, 1901, and Jan. 1, 1903, are classified as follows:

Steam jets and air blast	540
Down-draft furnaces	189
Brick arches	57
Automatic stokers	9
Electricity	27
Smokeless fuel	22
Total	844

This, Mr. Jones states, covers practically all the violators of the ordinance, as found on inspection, but he adds that "a number of the devices installed by the various plants are not giving entire satisfaction." In such cases the parties responsible are informed of the fact, and if no improvement results they are brought into the courts, "the results of which have been very satisfactory." The department leaves the choice of a remedy for smoke entirely to the violators of the law.

Mr. Jones states, in a letter to this journal, that there has been an estimated decrease, since Oct. 1, 1901, of 60 to 70% in dense smoke from station-

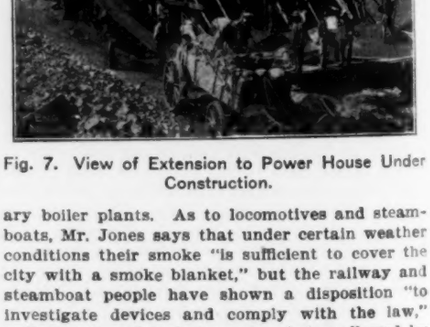

Fig. 7. View of Extension to Power House Under Construction.

ary boiler plants. As to locomotives and steamboats, Mr. Jones says that under certain weather conditions their smoke "is sufficient to cover the city with a smoke blanket," but the railway and steamboat people have shown a disposition "to investigate devices and comply with the law," sufficient time for that purpose being allowed by the smoke abatement department.

Those interested in attempts at smoke prevention in St. Louis prior to the law and ordinance

of 1901, will find an excellent review of the subject in the "Journal of the Association of Engineering Societies" for December, 1901. The review consists of a paper by Mr. Wm. H. Bryan, M. Am. Soc. M. E., read before the Engineers' Club of St. Louis, and includes an illustrated description of smoke prevention devices.

INVESTIGATIONS OF WATER WASTE IN NEW YORK CITY.

The new administration of the water department of New York city has begun a systematic investigation to determine what becomes of the immense volumes of water sent into the city daily from the Croton River, the streams and wells on Long Island, and other sources of supply. In making this investigation no small part is being played by the Cole-Flad pitometer, described elsewhere in this issue.

The accompanying table shows how the records of this investigation are being made available in convenient comparative form, as well as some of the results already obtained. Some of the figures for consumption and waste are also shown diagrammatically. Mr. Robert Grier Monroe is Commissioner of the Department of Water Supply, Gas and Electricity, and Mr. Nicholas S. Hill, Jr., M. Am. Soc. C. E., is Chief Engineer of the Department. We are indebted to the officers of the Department for a statement concerning the work, which we print as follows:

The department of water supply has for some time been making a survey of the distribution system in the Borough of Manhattan. The work has been carried on with the object in view of ascertaining what the actual use of water is in this city, and what the actual waste of water amounts to, and what proportion of that waste is due to leaks in the mains, and what amount can be accounted for by reason of defective plumbing in houses.

Districts of small area have been isolated by closing the valves or gates around the boundaries of these districts, leaving open certain mains, on which measuring instruments are placed. These measuring instruments give the quantity of all the water that flows into the isolated district during a period of 24 hours. The instrument used is the Cole-Flad pitometer. It is primarily a rate meter with a photo-recorder which indicates the flow during every hour of the 24, for which the meter is set.

Simultaneously with the measurements of the pitometer a house-to-house canvass is made to determine the leakage in the plumbing; the sewers are examined; the conduits for the electrical subways are looked into. If the flow into the district seems unaccountably large, then the district is further subdivded and cut off block by block until the point where the water is running to waste is located.

Up to the present time four districts have been thus treated and the results of the experiments in the first two are shown on the accompanying table and diagram. District No. 1 is bounded by 42d St. on the north, Lexington Ave. on the east, 34th St. on the south, and Sixth Ave. on the west. It may be considered a typical "brownstone" district. District No. 2 is bounded by 86th St. on the north, East River on the East, 90th St. on the south, and Second Ave. on the west. It contains a very large number of tenement houses.

In District No. 1, which can be designated as the Murray Hill district, the total resident population, according to the U. S. census of 1900, is 8,400. We found, however, that there was a large floating population in this district, on account of the many hotels. After a careful canvass it was ascertained that this non-resident population amounted to 3,760 people, so that it runs up the total population for whom water is provided in that district, to over 12,000 people.

The first pitometer measurement showed that in 24 hours 1,871,000 gallons of water came into this district. The district was then gone over very carefully. Where leaky plumbing was discovered in houses the occupants were notified and by cutting off the district block by block several small leaks and one or two serious leaks in the mains were discovered. A third reading of the pitometer, taken three weeks after the first reading, showed that 1,470,000 gallons of water were daily supplied to that district. The pressure during the 24 hours when the last measurement was taken was several pounds higher than the pressure during the time the first measurement was taken, and the indications are that 400,000 gallons of water a day have been saved by stopping the leaks in the mains and notifying private owners of defects in their plumbing. The per capita consumption in this district, if no account is taken of the floating or non-resident population, was, during the first measurement, 223 gallons a day. On the last measurement, 175 gallons a day. If, however, we add the non-resident population to the total resident population given by the census, the per capita consumption was 154 gallons a day on Dec. 17, and 121 gallons a day on Jan. 9

We have canvassed the number of people residing in hotels and houses where the water supply is metered, and the metered per capita consumption amounts to 128 gallons, which is about the general per capita consumption in that district. Another fact developed while these measurements were being taken, viz.: that the night flow, that is, the flow between 12 midnight and 4 a. m., was 90% of the average flow for the entire 24 hours. In other words, during the period when it is supposed that people cannot use water at all the average flow kept up. As a matter of fact, in the large hotels (the heaviest consumers), the water meter readings showed that water was being drawn from midnight until early morning at almost the same rate as during the daytime.

An inspection of the district also showed that a very large number of houses were supplied with tanks, and that these tanks filled as the pressure increased from midnight on, and that the tankage in that district after being measured, was found to be sufficiently great to account for the steady flow.

In striking contrast to this Murray Hill district is the second district, that has been measured; an upper East Side tenement district. This district has a population of nearly 40,000 people, according to the U. S. census of 1900, and uses 1,440,000 gallons of water a day. The gross per capita consumption is only 37 gallons, and if we take the actual leaks in the house plumbing, which we found and measured, the net per capita consumption is only 27½ gallons. In this district the night flow was only 50% of the day flow, instead of 90%, as in the Murray Hill district; and after the leakage in the house plumbing was deducted, the flow at night was very small indeed. The conditions in the district were entirely normal. There was no indication that there were any leaks in the mains and the only thing necessary was that the house plumbing should be attended to.

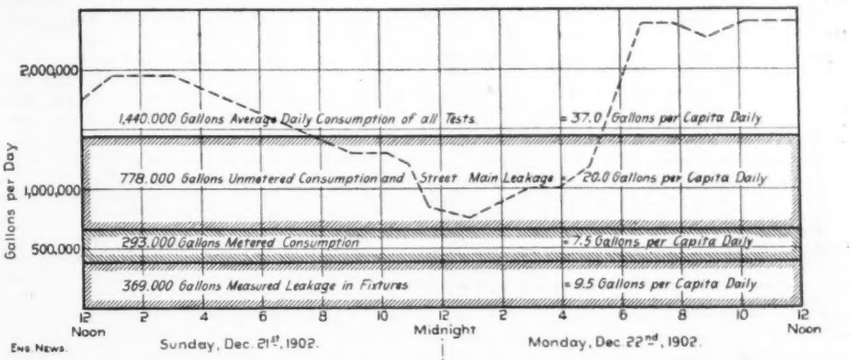

DIAGRAM SHOWING WATER CONSUMPTION IN TEST DISTRICT NO. 2, NEW YORK CITY.

A further comparison may be made between District No. 1—the Murray Hill district, and District No. 2—the tenement-house district. The daily supply of water in these two districts is approximately the same. In the first, 1,470,000 gallons, and in the second, 1,440,000 gallons. The leakage in the mains in these districts we believe to be very slight. The leakage in the house plumbing in the Murray Hill district, as far as can be ascertained, is a little over 40,000 gallons a day. In the tenement-house district the house leakage reported is 369,000 gallons a

PRELIMINARY RESULTS OF WASTE-WATER INVESTIGATION WITH THE COLE-FLAD PITOMETER, MANHATTAN BOROUGH, NEW YORK CITY.

	District No. 1.			District No. 2.
Test	No. 1.	No. 2.	No. 3.	No. 1.
Date of test	Dec. 17-19, '02	Dec. 21-22, '02	Jan. 9-10, '03	Dec. 20-22, '02
Population statistics:				
(1) Total resident population, U. S. census 1900	8,396	8,396	8,396	38,906
(2) Non-resident population estimated by canvass	3,760	3,760	3,760	.....
(3) Total population, resident and non-resident	12,156	12,156	12,156	.....
(4) Number of families supplied on frontage rates	1,104	1,104	1,104	7,771
(5) Estimated population on frontage rates	7,172	7,172	7,172	32,638
(6) Population metered—Resident [(1) — (5)]	1,224	1,224	1,224	6,268
(7) Total population metered—resident and non-resident (estimated); [(6) + (2)]	4,984	4,984	4,984	.....
Statistics of supply:				
(8) Total flow measured into district	1,871,000	1,700,000	1,470,000	1,440,000
(9) Total flow measured out of district	.....	.....	.....	.....
(10) Total daily supply, galls. per 24 hrs. [(8) — (9)].	1,871,000	1,700,000	1,470,000	1,440,000
Statistics of consumption: No. houses unmetered:	1,019	1,019	1,019	971
(11) Number of metered houses	389	389	389	174
(12) Gallons metered, average daily, records of Dept.	638,000	638,000	638,000	293,000
(13) To populat'n paying frntge rates [(10) — (12)]	1,233,000	1,062,000	832,000	1,147,000
(14) Total (12) and (13)	1,871,000	1,700,000	1,470,000	1,440,000
(15) Total plumbing leakage (house-to-house canvass)	42,429	42,429	42,429	369,000
(16) Net consumption and street leakage [(14) — (15)]	1,828,571	1,657,571	1,427,571	1,071,000
(17) Street main leakage found	.....	.....	.....	.....
(18) Net consumption [(16) — (17)]	1,828,571	1,657,571	1,427,571	1,071,000
(19) Gross per capita consumption* [(10) ÷ (1)]	223	203	175	37
(20) Gross per capita consumption†, [(10) ÷ (3)]	154	140	121	...
(21) Net per capita consumption*, [(18) ÷ (1)]	218	197.7	170.2	27.6
(22) Net per capita consumption†, [(18) ÷ (3)]	150.4	136.5	117.5	...
(23) Metered per capita consumption*, [(12) ÷ (6)]	522	522	522	46.8
(24) Metered per capita consumption‡, [(12) ÷ (7)]	128	128	128	...
(25) Ratio-minimum night consumption, avg for 24 hrs	0.90	0.90	0.90	0.50
Leakage inspection (House-to-house):				
(26) Number of buildings inspected	599	599	599	1,047
(27) " " buildings with leaky fixtures	161	161	161	713
(28) " " fixtures reported leaking	...	...	...	...
(29) " " ball-cocks reported leaking	...	...	...	...
(30) Sewer inspection, date when made	Dec. 17-18, '02	.....	Jan. 11-12, '03	Dec. 19-20, '02
(31) General results	Small flow.	.....	Small flow.	Small flow.
Financial statistics:				
(32) Yearly revenue from frontage rates	$18,115	$18,115	$18,115	$37,315
(33) Yearly revenue from meter rates.	31,000	31,000	31,000	14,550
(34) Total yearly revenue (32) and (33)	$49,115	$49,115	$49,115	$51,865
(35) Yearly revenue per capita,* [(34) ÷ (1)]	5.85	5.85	5.85	1.33
(36) Yearly revenue per capita,† [(34) ÷ (3)]	4.03	4.03	4.03	...
(37) Revenue,§ based totl consumpt'n $\left[(34) \div \frac{(8)}{1,000}\right]$	0.072	0.072	0.072	0.0088
(38) City meter rate per 1,000 gallons	0.133	0.133	0.133	0.133
Incidental information (night rate of supply):				
(39) Minimum night rate in gallons per 24 hours	1,740,000	1,600,000	1,300,000	720,000
Total number of metered houses in district	389	389	389	174
(40) Number of large meters read at night	20	20	20	7
(41) Total night rate, large meters read, galls., 24 hrs.	157,000	157,000	157,000	5,299
(42) Est. total night rate all meters, gallons pr 24 hrs.	574,000	574,000	574,000	150,000
(43) Night rate of net unmetered consumption	1,123,571	983,571	683,571	201,000
(44) Net unmetered cnsmptn per capita [(43) ÷ (5)]	157	137	95.3	6.1
(45) Approximate area of district, acres.	127	127	127	70

*Based on resident population. †Based on total population. ‡Resident and non-resident population. §Per 1,000 gallons.

day. The water sold by meters in the Murray Hill district is 638,000 gallons a day, and produces a revenue to the city of $31,000 a year, out of a total revenue for the entire district of $49,115. In the tenement-house district only 236,000 gallons are sold by meter, producing a revenue of $14,550, out of a total revenue of $51,861. From a small amount of water in District No. 2, and a larger amount definitely known to be running to waste, a larger revenue is produced, and this notwithstanding the fact that 40% of the water is metered in District No. 1, and about 20% in District No. 2.

On the total consumption in the Murray Hill district the city is paid a little over 7 cts. for 1,000 gallons. In District No. 2, the tenement-house district, the city is paid on total consumption nearly 10 cts. for 1,000 gallons. For water supplied on frontage rates, which we will consider as all the water that runs into the district, less what is actually measured by meters, we find that for 832,000 gallons a day supplied to District No. 1, the city receives a yearly revenue of $18,115, while from 1,147,000 gallons supplied to the upper East Side tenement-house district (No. 2), the city receives a total revenue on frontage rates of $37,315. These figures demonstrate not only the unfairness of frontage rates, but that the extra burden, as usual, falls upon those least able to bear it.

The flow in a third district has also been measured. This latter district is on the lower East Side, and is bounded by Grand St. on the north, the East River on the east, Market St. on the south, and Division St. on the west. It contains a population of about 90,000, and the consumption approximates 60 gallons per capita, but the plumbing leakage has been found to be very great, and has not yet been fully measured, and other data have not yet been completed.

The department has also arranged to measure the flow in a district on the West Side, down town, and in the apartment-house section west of Central Park. When these measurements are made and the inspections com-

The foregoing is now presented to the public, not with the idea that it is possible to make correct generalizations or sound deductions from an investigation that has only commenced, but in order that taxpayers may know what work is being carried on. By the time half of the area of Manhattan Island has been divided into districts, inspections made and measurements taken with accurate comparisons and computations, it will be possible to determine with comparative accuracy just what becomes of the water from the Croton shed, and just what condition our distribution mains are in. Effective remedies can only be applied after facts are fully obtained.

EXPERIENCE WITH FOUNDATIONS IN BOSTON.

The meeting of the Boston Society of Civil Engineers on Wednesday, Jan. 28, was devoted to the subject of "Foundations for Buildings and Engineering Structures." The principal paper was by Mr. J. R. Worcester, and was entitled "Boston Foundations."

The Boston building law does not allow any part of a structure to be designed for less than the full specified live load on each floor. When the foundation is reached, however, the law does not specify the allowable load per pile, or per square foot. It is probably safe to assume that not over 50% of the total live load on all the floors reaches the foundations.

The geologic formation of the "Boston Basin" is explained by Prof. W. O. Crosby, in an appendix to the fifth annual report of the Boston Transit Commission. The underlying rock, a slate formation, is at a depth of 50 to 170 ft. below low water. Above this is boulder clay 15 to 90 ft. thick; then a layer of blue clay with occasional layers of fine sand. This clay reaches an extreme elevation of about 5 ft. above high water. Where the clay has been eroded there is frequently found silt, often covered with peat.

Along the shore line, and between it and the original shore, all sorts of conditions are found. Old seawalls are frequently met with, and there is a great deal of wood, usually sound.

Solid rock is so far below the surface that it is practically never encountered in Boston foundations. In general there are but two classes of foundations in use, and structures are either supported directly upon the earth or on piles. The line of demarcation between the two classes, although not very definite, follows in general the original shore line.

The pile foundations are subdivided into two groups; first, where the piles pass through filled material, silt, mud, etc., to a hard underlying stratum of clay; and second, where the piles are sustained only by friction.

In a pile foundation the problems are:

(1) What is the best and most economical way to pile for a foundation?

(2) What loads can the piles safely carry?

(3) At what grade should piles be cut?

(4) How should foundation piles be capped?

Under (1) should be considered kind and size of piles, spacing, and specifications for driving, etc. The cheapest piles in this market are spruce; they range from 20 to 50 ft. long, 4 ins. to 6 ins. diameter at the tip, and 10 ins. to 12 ins. at the head. A pile not less than 6 ins. in diameter at the tip should be large enough for all ordinary foundations. When a greater length is required than can be had in spruce, hard pine or Norway pine can be obtained, in lengths up to 75 or 80 ft. The diameter at the butt for this length will be about 16 ins. The Norway pine piles are a little cheaper than the hard pine, and are practically as good. Ordinary spruce piles can be driven 24 ins. apart on centers, while large piles cannot be much closer than 30 ins. When the piles are supported by friction, and when there is friction enough to carry the soil between the piles down with them, the spacing is dependent on how much load the material will support per square foot. There is wide variation in the specifications for weight of hammer face and penetration. Where piles are driven into a hard stratum there is great danger of crippling them by too hard driving. The Boston & Maine R. R. specify a 2,600-lb. hammer falling 15 ft., with a penetration of not over 16 ins. in the last ten blows. Mr. Worcester advises a penetration of 1 in. under a 2,000-lb. hammer falling 10 ft., and a penetration of 3 ins. under a 2,000-lb. hammer falling 15 ft. when the piles are supported by friction only.

(2) The several formulas in use give widely varying values for the safe loads of piles. An old rule quite generally followed in Boston is to call the safe load 10 tons for pile. Many use the Engineering News formula, although designs are seldom changed in case the penetration, weight and fall are found to differ from those assumed. Mr. Worcester believes that with the condition of penetration, weight and fall suggested in a preceding paragraph, loads of 16 tons on piles reaching a hard stratum and 9 tons on friction piles would have a factor of safety of about 3.

(3) There seems to be an unwritten law in this vicinity that 5 ft. above Boston base, or about half-tide, is a safe level for cutting off piles. Besides being sure that the pile will be always wet, it is important that it should be so covered that worms will not have access to it. Mr. Worcester suggests that the masonry be started not higher than grade 4, where tide-water has access to the piles, and at grade 5 when the piles are fully surrounded with earth.

(4) The building law requires that "all piles shall be capped with granite block levellers." This would seem to exclude concrete, but in some recent work the Board of Appeal has allowed its use.

Foundations not requiring piles are generally of a simple character. In the higher parts of the city the foundations are about as simple and as satisfactory as if on solid ledge. The soil in these parts would probably carry 10 tons per sq. ft. without appreciable settlement; 5 tons per sq. ft. is frequently assumed as a safe load.

In low cellars, below grade 8 or 10, it is generally necessary to build a thoroughly waterproof bottom and wall. The safe load on foundations in the lower part of the city depends largely on the wetness of the soil. It probably ranges from 2½ to 4 tons per sq. ft.

The unequal loading of foundations caused by eccentric loads is frequently overlooked. This is especially likely to occur when walls are erected near lot lines. The system of supporting such loads on cantilever girders has been considerably used in Boston in the last 10 or 15 years. In some recent narrow buildings, foundation girders running across the whole width of the building have been employed.

DISCUSSION.

Mr. John E. Cheney, Assistant City Engineer of Boston, said that in his judgment, when floors are designed to carry a live load of 150 to 250 lbs. per sq. ft., walls and columns would be safe if computed for a live load of 50 lbs. per sq. ft. over the whole floor area. For city bridge work piles are specified to be not less than 6 ins. in diameter at the tip. The Engineering News formula is generally used in estimating the safe load for a pile. He had never heard of wood being injured by contact with mortar, except in one case where studding under the plastering in a house was ruined in a short time. It had been shown that in this case the lime had not been properly slaked, and it was supposed that the trouble was caused by free lime.

Mr. Henry Manley stated that nearly 30 years ago, when N. Henry Crafts was City Engineer, he had been given by Mr. Crafts the problem of determining the proper elevation at which to cut off piles, and after extended investigation had reported that grade 5 would, he thought, be safe in all usual cases; he thought that was the origin of the present practice of cutting piles at that grade.

Mr. F. Herbert Snow stated that on the Boston & Maine R. R. he had adopted the practice of laying concrete between the pile heads and starting stone masonry on that. He had found that if he placed concrete above the heads of the piles there was great danger of starting the masonry upon it before the concrete had set. He thought Mr. Worcester should have mentioned another class, crib foundation, as exemplified in Pier 7 at the Charlestown Navy Yard.

Mr. J. W. Rollins, Jr., mentioned some instructive experiences that he had had in his contracting work of the past year. In Virginia he built a pile trestle, the piles being driven into sand, and by Trautwine's rule it should have supported a load of 60 tons. A locomotive bringing a load of 30 tons upon it caused it to settle. On the Cambridge bridge they had occasion to drive many temporary piles a short distance into the gravel. When they were pulled the ends were found to be broomed. If the supporting power of these piles equalled the resistance they offered to pulling, it was tremendous. They generally found it impossible to pull the piles without breaking them. In some piers built at Portland, concrete was put in the bottom of a crib, and after a month when the crib was pumped out the concrete was found absolutely worthless. It had been made from one of the leading brands of Portland cement, which had been tested and found all right, in 1-2-5 proportions. The water was analyzed and reported nearly good enough for a drinking water supply. An examination of the river showed that there were a number of pulp mills above this point, and there seems to be no other explanation of the trouble than the effect of the waste from these mills upon the cement. Test batches of seven of the leading brands of Portland cement were immersed in the river one day, and all but one were worthless the next morning; the power of setting seemed to have been totally destroyed.

Mr. Davis said that it did not seem to him that a formula containing terms for drop and weight of hammer, and penetration of pile only could give satisfactory results. He used a formula of the form

$$S = \frac{W - p}{f},$$

where,

S = area of pile in contact with the earth, in sq. ft.

W = load on pile.

p = a factor for bearing of pile.

f = a factor for friction of soil,

the last two terms to be determined by experiment. It has been found that,

p = 5,000 to 6,000 for sand and gravel.

p = 0 for silt.

f = 100 to 300 lbs. per sq. ft. in soft material, 300 to 500 lbs. per sq. ft. in mixed material, 400 to 600 lbs. per sq. ft. in sand and gravel.

SUCCESSFUL TESTS OF ARTIFICIAL COAL made by a "chemical process" from lignite are reported as having taken place near St. Paul. Dr. Rudolf J. Schimper, the inventor of the briquetting process, claims to merely "hasten the process of nature" in converting lignite into coal. It is claimed that the "briquettes can be turned out at the rate of $1.25 a ton."